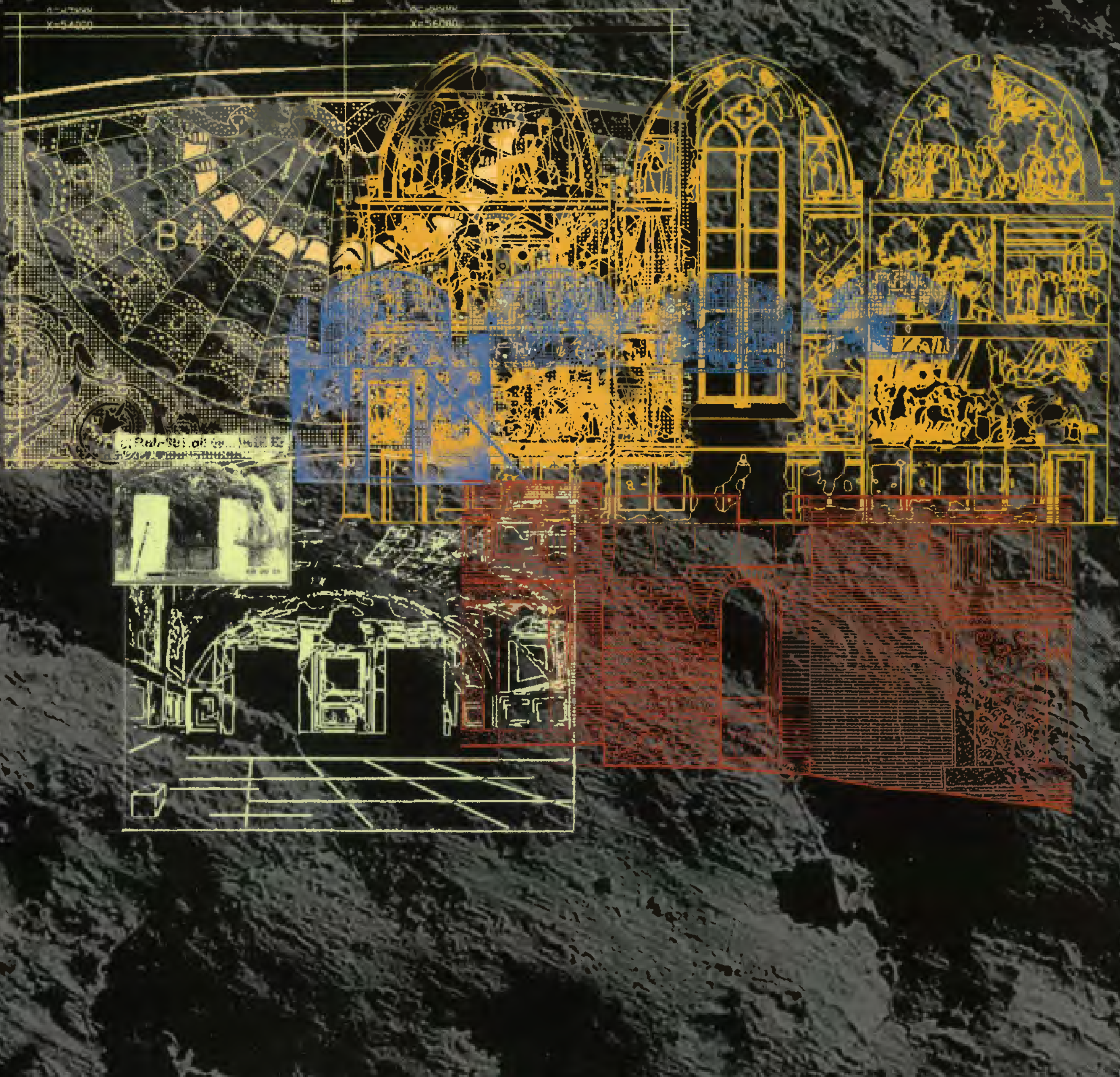
Research Seminar / Rome 16-20 November 1999

GRADOC

GRAPHIC DOCUMENTATION SYSTEMS IN MURAL PAINTING CONSERVATION



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Research Seminar / Rome 16-20 November 1999

GraDoc

Graphic Documentation Systems in Mural Painting Conservation

edited by Werner Schmid

ICCROM

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Contents

Foreword

The topic of the seminar whose proceedings are published in this volume was Graphic Documentation Systems in Mural Painting Conservation (abbreviated as GraDoc). It combines ICCROM's longstanding dedication to the specific field of mural painting conservation with the more general question of documentation of cultural property. As ICCROM's mandate requires, the contributions to the seminar are international in scope and relevant to a much wider field than mural paintings alone.

Any review of documentation methods raises a number of questions: why document? What constitutes adequate documentation? Who determines this, and who is responsible for producing it? What methods are most appropriate for recording, and for disseminating the results? And how can the records themselves best be preserved?

The seminar did not resolve all these questions, of course, but, as the volume makes clear, it gave rise to substantial contributions and a lively discussion. It reports both theoretical debate and practical guidelines, while also exploring the role of rapidly evolving technology in documentation systems. Technological advances make possible much more detailed documentation, as the papers collected here and the CD-ROM enclosed with them illustrate very well. They are contributing exciting new approaches to what remains the ultimate aim, namely ensuring the long-term preservation of decorated architectural surfaces which constitute an important element in our cultural heritage.

Nicholas Stanley-Price
Director-General
22 October 2000

Acknowledgements

An enormous number of persons and institutions have contributed directly or indirectly to this project and to the publication of its results.

ICCROM and the co-organizing partners would like first of all to thank the European Union for electing this GraDoc under the Raphaël 1999 Programme, which has allowed us to give the project the broadest possible scope. We are also grateful to The Getty Conservation Institute (GCI) and English Heritage (EH) for having provided additional funding towards this publication, thus permitting us to include more material than initially planned. Furthermore, the Istituto Centrale per il Restauro (ICR) in Rome contributed substantially in staff time and expertise.

Special thanks are due to the directors of all partner institutions, namely the Wall Painting Department of the Courtauld Institute (CIA), London, the Getty Conservation Institute, Los Angeles, ICOMOS-CIPA, the Institut Royal du Patrimoine Artistique (IRPA), Brussels, the ICR, the Consiglio Nazionale delle Ricerche (CNR) – Area di Ricerca di Roma – and the Niedersächsische Landesamt für Denkmalpflege (NLD), Hannover, Germany.

GraDoc is the result of an intense and fruitful joint effort and we would like to acknowledge the tireless enthusiasm and commitment of the group of specialists who co-operated in all phases of the project: Giancarlo Buzzanca (ICR), Sharon Cather (CIA), Maurizio Forte (CNR), Rolf-Jürgen Grote (NLD), Robin Letellier (ICOMOS-CIPA), Gaetano Palumbo (GCI), Francesca Piqué (GCI), and Walter Schudel (IRPA).

We are also grateful to the editorial board for their contribution to the final project phase. The board was composed of the facilitators of the three working groups: Adrian Heritage (EH), Robin Letellier, Gaetano Palumbo and Francesca Piqué.

Thanks are also due to Cynthia Rockwell and Thor Lawrence for the editing of the printed publication, to Maurizio Forte for editing the supplementary CD-ROM and to Lorinda Wong for her assistance in preparing and running the seminar and for her knowledgable input.

Finally we would like to express our thanks to all seminar participants for their contributions and their commitment, which went far beyond the seminar itself.

Introduction

"In all works of preservation, restoration and excavation, there should always be precise documentation in the form of analytical and critical reports, illustrated with drawings and photographs".[1]

Following this general recommendation formulated more than 30 years ago, the documentation of all steps of the conservation process has grown in importance. Nevertheless, a lack of adequate understanding of the purpose and technical requirements of documentation in general (and graphic documentation in particular) has created a sense of uncertainty amongst conservation professionals, especially with regard to matching the type of documentation and the level of detail to specific project needs.

Some conservation projects seem to be over-documented, accumulating information that is difficult to access and might never be used in the future. In others, the need to document is still not recognized sufficiently or budgeted for. Budgets for cultural heritage conservation are extremely limited and allocated resources must be cost effective.

Evolving computer technologies offer continuously new possibilities of recording and managing information and increasingly require the close co-operation of professionals from disciplines who were not formerly involved in the heritage field, such as documentation and computer specialists.

In recent years, and especially in the field of conservation of mural paintings, a notable amount of experience has been accumulated with regard to the application of innovative documentation systems. This experience has never been properly evaluated and professionals in charge of these projects have not met sufficiently.

These are some aspects of the context in which ICCROM decided to include a research seminar dedicated to these issues in its biennial programme for 1998-99.

Within the Organization, the seminar was managed by SURF – a framework programme for all ICCROM activities in the field of conservation of architectural surfaces, including mural paintings, mosaics, stone, historic façades and rock-art. ICCROM's long-standing experience with training in this field, especially with the Course on the Conservation of Mural Paintings (MPC),[2] as well as discussions, participants' surveys and direct field work on recent editions of this course and the input and encouragement of former participants, were decisive elements for the development of GraDoc.

The project development

The first step in the project development was a bibliographic research to collect and evaluate relevant literature and existing guidelines on this theme, the results of which are published here.[3] It appears that the part dedicated to documentation in the standard work *Conservation of Wall Paintings,* by Laura and Paolo Mora and Paul Philippot,[4] continues to be the most widely observed 'guideline' in this specialized field of cultural heritage conservation.

A second result of this research was the identification of institutions and individuals that might be willing to share their experience and expertise and become potential contributors to the seminar.

In late 1998, a consortium of eight organizations was established with an agreement to share responsibility for the development and implementation of the project, with ICCROM in a co-ordinating role. In February 1999, the project partners met in Rome for a two-day planning meeting to define the goals, contents, structure and expected outcomes of the research seminar.

Mural paintings combine image and architecture. It was recognized that documentation in mural painting conservation represents a particularly complex challenge, involving the collection, recording, correlation and interpretation of an extremely broad range of data from the most different areas, both at a macroscopic scale and in relation to the building envelope. The focus on mural paintings was agreed with the purpose of facilitating discussion, but also with the conviction that the results of the seminar would be relevant for the documentation of other types of heritage and in particular of related architectural and decorated surfaces.

Graphic documentation, considered as part of conservation documentation as a whole and within the framework of conservation and management of cultural heritage, was defined as the second focus. It was felt that graphic documentation, albeit only one of the three main components of a complete documentation set (which also includes descriptive and other visual information units) is certainly the most debated aspect.

It was decided to design the seminar as a discussion platform for 'providers' (i.e., documentation and/or computer specialists) and 'users' (conservator-restorers, conservation managers and related mural-painting specialists) aiming to:

- assess the present situation and evaluate the use of new technologies through the discussion of recent experience, presented by the various professionals involved;
- contribute to clarification of the purpose and the correct use of conservation documentation in general and graphic documentation in particular;
- disseminate results to the international conservation community.

Following the planning meeting, the GraDoc partners applied successfully for additional funding to the European Union under the 1999 Raphaël Programme.

The seminar

Twenty-six invited experts from sixteen countries participated in the five-day seminar, held at ICCROM from 16-20 November 1999. The ratio of 'providers' to 'users' was about one to three, including architects, archaeologists, art-historians, conservator-restorers, conservation scientists, surveyors, computer and documentation specialists and all possible combinations of the above.[5] Fifteen other experts, most of them from Italy, joined the group on the fourth day, which was dedicated to the demonstration and evaluation of computer-aided documentation systems and information databases. A selection of these demonstrations can be viewed on the CD-ROM which accompanies this publication.[1]

The papers, as they are published here, reflect the sequence in which they were presented and the structure of that part of the seminar. All papers express the personal opinion and experience of the authors.

Part I – dedicated to aims, methods and standards of graphic documentation in mural painting conservation – includes eleven papers which cover a very rich and varied range of arguments. Walter Schudel's critical remarks stress the limits of documentation and open the floor to a less technically oriented discussion. Francesca Piqué, Jürgen Pursche and Konrad Zehnder discuss basic concepts and describe a methodology as well as its adaptation to specific cases. Sharon Cather addresses the issue of documentation being inadequately recognized and budgeted for. The evolution of documentation practice and the matching of the level of documentation to project needs and available resources is amongst the issues treated by the contributions of Haydee Orea Magaña and Jun Zheng. Nimal de Silva describes a methodology developed for the documentation of mural paintings, which also involves the production of full-size copies. The documentation of the time factor and the possibility of recording dynamic processes are the main subjects of the contributions by Jacques Neguer and Adrian Heritage.

A set of fourteen papers constitutes part II, which is dedicated to the critical evaluation of digital graphic documentation and databases and to case studies under this topic. Heinz Leitner opens this section with problems faced by a private conservator when entering the field of computer-aided documentation - a personal testimony that introduces the discussion of pros and cons. Elke Behrens describes in detail the standard methodology for graphic documentation developed by her office and draws a comparison between manual and digital approaches. Gaetano Palumbo's paper gives a 'user-friendly' introduction to the use of CAD and GIS software for graphic documentation, as well as recent examples of application. The issue of customization of CAD is discussed by Giancarlo Buzzanca and from an applied point of view by the case studies of Marcella Orru/Corinna Ranzi and Simon Warrack. The papers of Elena Murariu/Florian Petrescu and Rafal Szambelan provide more field experience and trials using a combination of CAD and GIS. Details about the information technology applied to two of the most prestigious mural painting conservation projects of the last 20 years are presented by Filippo Petrignani for the Sistine Chapel and by Stefano Casciu, Giuseppe A. Centauro and Massimo Chimenti for the murals by Piero della Francesca at Arezzo. Rolf-Jürgen Grote, together with Annette Hornschuch and Jürgen Heckes, convey their experience with establishing a regional wall painting database, and describe the diagnostic possibilities offered by multispectral analysis. The issue of creating 3-D models and of using them as a basis for the input of various documentation formats is developed by the contribution of Robin Letellier and by the joint papers of Maurizio Forte, Angela Bizzarro and Stefano and Alessandro Tilia and of Luca Menci, Francesca Ceccaroni and Paolo Salonia.

With the intention of creating a common language for the seminar, a draft terminology was circulated amongst paper authors in view of the preparation of their contributions for the pre-prints. This terminology - given in Chapter 28: Glossary of terms used for GraDoc - provides draft definitions of some of the most arbitrary terms relating to documentation principles and methods and of some key terms used in computer technology. It is important to stress that this terminology is merely a working document and does not pretend to be anything more than this. The difficult task of creating a possibly multi-lingual terminology relating to conservation documentation would be well beyond the scope of this project.

The circulation of pre-prints prior to the meeting made it possible to reduce the time for presentation of papers, leaving ample room for discussion. A transcription of the discussions that followed each paper is part of this publication.[7] We hope that this transcription, apart from providing additional information and clarifications, will give our readers a feeling of the debate and the atmosphere during these intense and highly productive days.

About half of the available time was dedicated to interactive working-group sessions with the goal of developing a Framework Document, which would eventually provide the basis for the production of guidelines for graphic documentation of mural paintings. Three working groups were established, each dealing with a different problem area.

To facilitate discussion, a previously developed list of relevant issues was provided which was modified and adapted by the working groups during a first session. Another essential document for discussion was the summary of a questionnaire on Condition Recording in the Field of Wall Painting Conservation, carried out in 1997 by Lorinda Wong as part of her postgraduate diploma dissertation on this theme accomplished at the Wall Painting Department of the Courtauld Institute of Art, London.[8]

One working group had the task of analyzing the function of documentation in mural painting conservation and the specific function of graphic documentation, asking questions such as: *Why do we document? What types and levels of information should be documented? Who produces documentation? Who uses the documentation? How can graphic documentation be used as a management and monitoring tool?*

The second group analysed the graphic documentation process, including technical issues such as planning, data collection and data organization. Some of the questions discussed were: *Should graphic documentation be standardized? What are the pros and cons of different types of base maps? How can/should curved surfaces be represented in 2-D output? How can we reduce the loss of accuracy from the initial record through the documentation process to the final version?*

The third working group, the so-called 'Techno Group,' dealt with the use of new technologies. This group concentrated on the pros and cons of using computer-aided graphic documentation and relational databases. Other issues covered cost-effectiveness, and the role of the documentation specialist, as well as the knowledge and skills required. The working group also tried to critically compare software in current use and to provide an overview of recent developments and future trends.

Four half days were definitely not enough for finalizing a document that would reflect the often controversial opinions that were expressed. Following the seminar, an e-mail distribution list was established amongst participants in order to continue the discussion and to further develop the documents drafted by the three working groups. The results published here are neither guidelines nor a framework document, but rather a discussion paper for continued debate with the participation of a broader segment of the international conservation community.[9]

GraDoc was not a point of arrival but hopefully the beginning of a series of initiatives at national, regional and/or international level, which eventually might lead to an agreement on principles and practices in documentation of mural paintings and related architectural surfaces. Perhaps the same information technologies, which are offering new possibilities in conservation documentation, will allow us to achieve this by using innovative ways of communicating and sharing our thoughts.

Werner Schmid
October 2000

1 Article 16 of the International Charter for the Conservation and Restoration of Monuments and Sites (Venice Charter), 1964.
2 MPC, the international course on the conservation of mural paintings was first organized in 1968. Since then it has been attended by more than 600 conservation professionals from more than 60 countries, representing an important international reference for continuing professional development.
3 See: Selective survey of existing guidelines in conservation documentation, Chapter 23. See: Selected bibliography on computer-aided documentation, given on the CD-ROM.
4 1st edition in French: *La Conservation des Peintures Murales*, Bologna: Editrice Compositori, 1977. 2nd edition in English: *Conservation of Wall Paintings*, London: Butterworth, 1984. 3rd edition in Romanian: *Conservarea Picturilor Murale*, Bucharest: Meridiane Publishing House, 1986. 4th edition in Italian: *La Conservazione delle Pitture Murali*, Bologna: Editrice Compositori, 1999.
5 For list of seminar particpants see Chapter 29.
6 Please note that the aim of publishing this CD-ROM was to accompany and expand on the contents of papers by the same authors. It is meant as an integral part of this publication and not as a separate product.
7 See: Transcription of discussions following paper presentations, Chapter 25.
8 See: Survey on condition recording , Chapter 27.
9 See: Results of working group activities, Chapter 24.

1

DOCUMENTATION OF INTANGIBLES

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A B S T R A C T

In order to successfully conclude the conservation-restoration of a mural painting, it is necessary to know how that particular work of art 'functions.' All types of documentation have their possibilities and impossibilities. The 'functioning' of a work of art (mural painting) depends also on quite a lot of non-measurable parameters. How can these be documented?

KEYWORDS: *art implementation; restoration; documentation.*

INTRODUCTION

Conservation documentation often seems to be intended to make an impression on policy makers: bulky reports of the (necessary!) preliminary research have to be made before funds for the subsequent treatment are made available. After the intervention, certain report materials are expected so that the politicians can show off with 'their' heroic deeds and people can see that their tax money has been spent for a good cause. Obviously such exercises obey the rules of the art of politics: after all, politicians (and conservators as well) have to find ways to promote themselves.

Completely opposite in the spectrum of motives for building up conservation documentation is the goal – much more modest in as far as form is concerned, but certainly much more ambitious in terms of content – of providing conservators with the necessary insight and indispensable self-discipline for their practical work.

Two quotations set the scene. The first is well known to anyone involved in restoration. It comes from the Charter of Venice, Article 16, which is directly related to documentation of conservation:

> "....in all work of preservation, restoration and excavation, there should always be precise documentation in the form of analytical and critical *reports*, illustrated with *drawings* and *photographs*." [Author's underlines and italics.]

The second quote is the title of this seminar:
"Graphic documentation systems in *mural painting* conservation."
Taking both quotations together one might think the seminar was about what the Charter of Venice calls: illustrations ('illustrated') "with drawings and photographs."

It seems to me important to notice that photographs and drawings can also be, perhaps even should be, critical and analytical. Each medium should be used according to its own communicative value, not 'only' as an illustration. At the same time, one should also be aware of the shortcomings of each communication medium. Reality as such cannot be communicated.

That is the first point to be made: the media-message relationship.

This seminar deals mainly with conservation documentation issues. Indeed, documentation in connection with mural paintings, which is in connection with art. As stated above, it might be of interest to use those documentation systems that are best adapted to reveal the particular characteristics of the object(s) or phenomena under consideration. In our case this is art (mural painting).

So we have to speak about art. That is the second point to be made.

Art

It is well known among professionals that restoration can no longer be considered as going back to the 'original' state. This is a fight that ended, on paper at least, some hundred years ago (cf. Dehio and Riegl, 1988). 'Refreshing' of colours by means of glue, varnish, etc., a widely and officially accepted practice in the past, has been abandoned, although it continues, semi-officially by means of Paraloid and barium hydroxide. The key issue to be considered is the work of art, both in its artistic and historical features, as it has come down to us (Doerner, 1965). This viewpoint overthrows the (romantic) view that considers a work of art as a unique creation to which nothing can be added or subtracted. But then, what might be the meaning of an aged, perhaps even a damaged work of art?

It is clear that this vast subject can hardly be tackled in this venue, yet it cannot be avoided, either. Indeed, no treatment (let alone proper conservation documentation) of a work of art will be possible without an understanding of the issues involved in the process. This understanding is even more important if one takes into consideration that any intervention of the conservator will change, more or less, but nevertheless unavoidably and irreversibly, the physical and visual properties of the already irreversibly changed (by ageing) appearance of the work of art.

This can be explained in a quite (maybe too) schematic way:

Conservation of mural paintings is based on three elements:

- Science
- Creativity
- Practice

Graphically (to stick to the seminar theme) this concept could be represented as follows:

- Practice
- Science
- Creativity

Science and creativity are the basis for conservation practice. In the triangle, a circle has been drawn to show clearly that, as in all typologies, the pure types do not exist. The conservation-'reality' within the circle is therefore always a mix of the three elements.

Science

The role that science and documentation can play in conservation was, in my opinion, very well formulated by Arnheim (quoting Holton):

> "...Science, just as art, can only function if it spans the total range from direct, empirical perception to formalized constructs and maintains continuous interchange between them. Severed from their referents, stylized images, stereotyped concepts, statistical data lead to empty play with shapes, just as the mere exposure to first-hand experience does not assure insight."
> (Arnheim, 1984: 308)

Seeing and knowing are closely connected. That is why science is helpful in assuring insight. This science, in our case, is first of all art history, which helps one to situate a work of art in time, space and style. Other 'humanities' disciplines can also be quite helpful, e.g., philosophy, anthropology and sociology. Furthermore, there are all the nat-

Figure 1. St Joseph, detail of "The Nativity", original, 1448.

Figure 2. Philip the Good, detail of "The Nativity", reconstruction, mid-19th century.

ural sciences that can be helpful in identifying aspects of the work of art: chemistry, biology, physics and so forth.

Creativity

The word 'creativity' has been almost totally banished from the conservator's vocabulary since they have had to abstain from arbitrary decisions. This situation is unfortunate: first, because all problem solving demands creativity; and second, creativity is our special concern here, because a work of art does not speak for itself. A work of art can only communicate or function if there is a relationship between the object and the subject.

Historical substance is one aspect of authenticity. The possibility of functioning, of establishing a relationship between the work of art and the subject, for instance the conservator, is another indispensable aspect of authenticity.

The problems a conservator encounters could partly be compared with the problems confronting a performance artist. The latter has a music score or a script, which of course are not yet music or theatre. What the performer can and has to do is to analyse the score or text and carry out a study of the ways of performing it. In principle one could start performing at this stage, just like a lacuna might be filled after an analysis of its environment or, if necessary, after a study of other works of art by the same master or by representations from the same period as the work to be treated.

Like it or not, every action carries the personal touch of its agent. In the case of performing artists, the performance would lack personal character and taste if they did not make a deliberate choice or take a clear position, and in so doing did not leave their mark on it. The preparation process involves periods of unbiased (disinterested) study of the basic material (script or score) with periods when some personal choices are made, partly before and partly during the performance itself (cf. Stolnitz, 1961).

The same holds true for the conservator involved with a damaged work of art. The 'listening' period will probably play a more important role than in the case of the performing artist, but eventually some personal choices will also have to be made. From the diversity of values in the work of art, only some of them will be highlighted (cf. Eco, 1965).

Before conservators begin the practical work, they therefore need to engage in a basic conceptual dialogue with the art object, seen in all its aspects. The report delivered as a result of this dialogue is an item of conservation documentation that has a key significance for conservation work: this documentation records non-measurable (intangible!) data. It should shed light on the criteria the conservators use to make choices, and on their approach to the treatment of the art object.

It is of primary importance that the work of art functions, in one way or another, and that conservators realise that it is partly through their intervention that the art object functions in one particular way rather than another (cf. Goodman, 1982).

Practice

The third, and decisive, pillar on which the conservation of works of art rests is practice. It is precisely practice that distinguishes the conservator from the scientist. The conservator has to do something. When a painting flakes off, it either has to be left like that or it has to be fixed. The practician cannot leave the question 'open.'

If those three elements are indeed the pillars on which restoration rests, then there is no reason not to document them properly. In consequence, a considerable amount of intangible information, as mentioned under 'creativity,' should be documented.

Medium and message

It seems that every system of documentation has its own possibilities as well as its specific limitations. A photograph taken as a document can be very useful indeed, but it represents only specific aspects of 'reality,' codified in a specific way. As long as one reads this code as a code and does not confuse it or mix it up with the notion of so-called 'reality,' the photographic document has its practical value for the conservator.

The same holds true for a map. People who like trekking know to appreciate an accurate recording of rock formations, small paths and rivers, etc., but the same map will most probably not be an adequate representation of the landscape's impact on the trekker. What is missing is the empirical impression (cf. Arnheim's quote above). The map and the empirical impression are also imperative for territorial management.

The conservator, too, needs measurable data (maps), but must not forget that such information has to be considered as a function of intangible information – the empirical impression.

How can non-measurable data be documented? I fear there is no other answer than by writing and by drawing.

It has often been stated that writing and drawing are time consuming, hence an expensive drawback, but analysing a work of art is of necessity time consuming, because it implies a high degree of thinking and decision making, as do writing and drawing.

In fact, drawing and writing are methods of analysis, and contrary to what one might believe, they are within closer reach of an average conservator (and citizen!) than is taking a fair photograph. The easy process of pressing the button of the camera is so blindfolding that in general we do not quite understand exactly what we are doing with it. The same might (actually I fear 'will') be true for other high-tech information systems.

Measurable data can best be documented by varying degrees of high-tech information systems (photographs included). The objective reality, however (whatever that might be), whether it is art or not, cannot be fully measured – far from it, and I must confess that I am happy about that. The most adequate thing to do, at least in the field of the arts, is to give our points of view concerning the artistic reality in those aspects that matter in respect to the ensuing conservation-restoration treatment. Precisely this can be done so marvelously by careful writing and drawing.

Moreover, such manual documentation systems deliver a great deal of incidental information (as high-tech systems might do, but how we know not yet). Numerous 19th century copies and calques of medieval murals, for instance, give us plenty of additional (unintended) information on how the Gothic period was perceived at that time. It is a way of seeing that is quite different from ours and, as a consequence, the restoration practices then differed significantly from ours. How differently people saw, among other things, appears also from the way they retouched paintings over a hundred years ago (Figures 1 and 2). In their time, they integrated the retouching with the original paint layers in such a way that the traces of their intervention could not be distinguished from the original. Nowadays, the same retouching is clearly recognized as 19th century style.

We can learn from the documentation of our predecessors, not least from their incidental information. We will also deliver such unintentional information ourselves. It is to be hoped that this information will not be that we did not care about art, rather that we cared only about paint flakes, salt efflorescence, micro-organisms, etc., and, especially, their respective quantifications.

Spirit and matter, medium and message, they will always maintain an ambiguous relationship. That is what matters, and it will never ever be measurable.

So do whatever you want to do, but make it clear, first of all for yourself, second for others now and in the future, what your **opinion** is about the work of art and why you plan to act, in consequence, in that particular way. This is the core of all documentation.

Consider the sentence:

> "Converting a canvas into something which can be discussed in philosophical terms is too broad an ambition to be encapsulated by a neat formula".

and then change 'canvas' into mural painting, 'philosophical terms' into artistic terms (or leave this as it is) and 'neat formula' into measurable data.

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2
BASIC CONCEPTS OF DOCUMENTATION

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A B S T R A C T

Basic issues in achieving worthwhile documentation are: directing the final goal; consistency and clarity; truthfulness and relevance; and accessibility and usability.
Three documentation types are distinguished: (1) preliminary documentation, to identify the problem and direct further investigations; (2) systematic and comprehensive documentation, to provide an overview and the necessary details on the subject; and (3) supplementary documentation, associated with interventions or any long-term monitoring.
Five basic steps in the process of documentation are: (1) Preparatory work; (2) Fieldwork; (3) Laboratory investigations; (4) Overall evaluation of results; (5) Supplementary assessments.
KEYWORDS: *documentation concept; methodology; scientific documentation.*

INTRODUCTION

Documentation means both the process of collecting and storing information, and its product in the form of written documents, maps, photographs, drawings, etc. So documentation fulfils three purposes: (1) to acquire, (2) to release, and (3) to store specific information. Although here we are dealing with documentation in the field of conservation of mural paintings, the basic concepts of documentation are the same as in other fields.

The ideal of performing documentation in parallel with the conservation work is – at least in Switzerland – in opposition to a market-driven situation, where the cheapest tender is favoured. That means that there is no provision of funds for investigations to prepare and clarify a situation and provide appropriate documentation. Nevertheless, the need for proper documentation has been accepted since the Charter of Venice in 1964, and it continues to be indispensable for conservation and the sustainable care of monuments.

The following outline of basic issues and steps in documentation emerges from our practice as natural scientists working in material investigations, damage diagnosis and conservation consulting on monuments.

Basic issues

The first issue is to *keep the final goal in view*. Our goal is to preserve the wall painting in its authentic structure and in a favourable condition. In order to do so, it is appropriate to perform the steps outlined in Table 1.

Table 1. Basic steps in monument preservation

1) Recognize the physical object, its materials and structures	materials assessment
2) Assess the state of preservation	damage assessment
3) Recognize and monitor the decay and its evolution	damage diagnosis
4) Evaluate the present and future risks	risk evaluation
5) Deduce the interactions for conservation	conservation strategy
6) Execute the necessary measures	conservation measures
7) Monitor further evolution	control of success
8) Continue and improve maintenance	maintenance and care

Source: Based on Arnold, 1994.

Particular documentation may be usually restricted to one or another specific purpose within this overall frame. However, it should fit in this context and contribute to attaining the final goal.

The second issue is *consistency and clarity*. In order to be consistent, documentation needs a clear structure. For instance, the standard structure of a scientific report contains the elements shown in Table 2.

Table 2. Standard structure of a scientific report

SECTION	EXAMPLE
1) *Definition* of the subject	Müstair (Switzerland), convent church, mural paintings in the apses: Investigation on the evolution of gypsum veils.
2) Description of *circumstances*	Investigations were done by observations on site during visits from 1984 to 1999, and by microscopy in the laboratory of samples collected.
3) Description of *facts*	The veils consist of gypsum. Aggregates of 0.1 - 0.5 mm in diameter grow on the surface of the walls in zones that have accumulated hygroscopic salts from rising damp. The veils produce a comparatively slow material loss in the form of powdery decay of the painting surface.
4) *Interpretation* of results	The gypsum veils have developed over more than 10 years. They now seem stable.
5) *Conclusions*	The specific crystallization conditions for gypsum veils are still unclear. There is some slow decay in related areas. However, there is no urgent need for interventions.

These five elements together form a consistent message. The first identifies the subject, and it defines and demarcates the purpose. The second notes the methods used, the conditions under which they were implemented, the participants, etc. This is – in a scientific context! – necessary in order to make the information comprehensible and reproducible. The third element, i.e. the description of the facts, is the core of the documentation. It always contains text, and in some cases also photographs, maps, drawings, etc., as appropriate to the subject and the circumstances. In good documentation, the whole is not too voluminous, but nevertheless as comprehensive as necessary. The fourth element is the evaluation of the facts. It establishes the significance and relevance of the facts, which is as essential an action as the description of the facts themselves. There are at least two reasons for this: first, our perception (cognition) is not objective. So the interpretation is an aid in getting the necessary critical distance between the author and the observations. Secondly, observations lead to new insights, which may become the essential 'facts'. However, it is fundamental to the scientific method to keep these two steps as distinct as possible. Hence primary information and interpretation form a complementary pair. The fifth element considers the consequences of the investigative work, and future implications.

The third issue is *truthfulness and relevance*. Documentation should provide precise answers to precise questions. This obliges the reporter to sort out the relevant information. The documentation is at best as true, comprehensive and relevant as the matter was clear to the authors. At the same time, it can also be valuable to provide fragmentary items of information if they are appropriately qualified. This of course requires a high competence level and experience on the part of those involved.

The fourth issue is *accessibility and usability*. The documentation is directed to particular users (owners, architects, conservators, scientists, etc.), and it must be accessible and comprehensible in a short time. According to Levitt (1997), 'accessible' means, simply, that you can get at or get to the information when and where you need it. The same holds true for 'usable'. Otherwise the documentation in effect does not exist, or is useless.

DOCUMENTATION TYPES

The documentation is both the process and result of learning by investigating an object, and by collecting and evaluating related information. Physically it consists of text (always!) and additional material, such as maps, photographs, sketches, analytical results and other information. With respect to scope, there are three documentation types:

- ***Preliminary documentation.*** This defines the problem and associated questions. So the documentation has to provide a survey of what is already known and what has to be investigated more systematically. It contains preliminary results that indicate the direction of further investigations. It should provide a reliable basis for assessing the needs and expense of any further investigation required.
- ***Systematic and comprehensive documentation.*** In this stage, an appropriate overview is provided of the subject matter. Such documentation does not inevitably result in gigantic and expensive reports. The purpose is simply to get an overview of the situation as a whole, to sort out the relevant facts, and to answer the questions that guided the investigation. The particular procedure reflects the items in Tables 1 and 2, both in content and sequence. The documentation provides, for example, sufficient detailed information on the affected materials, on their present condition, on the relevant decay processes and their evolution; it interprets the chemical analyses or climatic data collected; it evaluates present and future risks; and it deduces potential interventions. In 'simple' cases, getting an overview of a given matter seems to be evident and easy; unfortunately in many documentation exercises it is not so! In complex cases, the overview documentation is just one step, to be followed by further investigations and documentation (see next point). It has to be borne in mind that all items of information are valuable only if they fit into the context of the problem, if they are correctly interpreted, and if they provide answers to the basic questions. Otherwise they are useless or misleading.
- ***Supplementary documentation.*** On the basis of sufficiently detailed and comprehensive (overview) documentation, suitable interventions, further investigations, monitoring, etc., can be planned and performed, which themselves will be the subject of discrete documentation.

Each of these documentation types has its specific purpose. Within a sequence of investigations and interventions on a particular object, these types normally follow in sequence. In such cases, the different documentations must be coordinated by a conservation scientist. For the definition of a conservation scientist, see the 'Bologna Document' (Anon., 2000).

BASIC STEPS IN THE DOCUMENTATION PROCESS

Documentation always has a specific purpose. Instead of a standardized documentation procedure, we first try to group the questions arising from the particular situation, and then to be guided by and respond to the situation itself. Of course, one establishes a kind of personal standard procedure with time, so that the documentation process will be carried out according to individual experience and skills. In general, the following methodological steps are performed during the process of documentation.

Preparatory work
This involves the collection, perusal and evaluation of existing and relevant documents, and provision of the necessary facilities, plans, etc., for the investigation and related documentation.

Field work
In essence, it consists of identifying the object; assessing the materials, damage and threats; and mapping out a (usually) complex situation. Particularly at this stage, **observation is the key to understanding!** Documentation serves as a medium to collect, collate and disseminate the observations made and related information. At the same time, documentation is the best means to observe exactly, for it obliges us to reproduce what we see and what we think. As a basic principle, **we can only document what we see, and we can only see what we know or think we know.** To recognize means to see and to combine new information with what we already know, which is a creative process. In describing and documenting a phenomenon, we have to be honest. One approach is to describe only what we are able to see, rather than interpreting other things that are not yet confirmed. That precludes many misinterpretations. To recognize damage is not as easy as it seems, since different causes (and processes) may lead to a similar visual aspect. This is illustrated by what is called a 'veil' (Table 3). Figure 1 shows an example of a gypsum veil, caused by the powdery efflorescence of gypsum ($CaSO_4.2H_2O$) on the Romanesque wall paintings in the convent church of Müstair [width of detail: 13 cm]. The whitish coating consists of tiny gypsum crystals (length between 1 and 100 µm) mixed with small paint particles. In the central area in Figure 1, the veil has been removed with a soft paintbrush. In Figure 2, gypsum crystals of such a sample are shown in a scanning electron microscope (SEM) image [width 30 µm].
Another phenomenon that is easily misinterpreted is dark spots in the basal zone of walls. These spots are normally considered as areas of increased humidity due to rising damp. However, darkening can be caused by quite different processes, including (1) increased humidity, (2) dust and soot deposition, or (3) encrustation or covering by thin salt crusts. As an example, a closer inspection during the damage assessment on the wall paintings in the convent church of Müstair (Switzerland) revealed that such dark spots were as dry as the wall surface inside (Figure 3). Further investigations showed that the surface was covered there by thin crusts of hydromagnesite ($Mg_5[OH(CO_3)_2]_2.4H_2O$). In that case, this scarcely soluble salt could be traced back to a treatment of the paintings with a water-glass product for consolidation some ten years previously. Hydromagnesite formed by a chemical reaction of sodium (or potassium) carbonate from the water-glass product with the indigenous salt solutions from the rising damp. They contain magnesium ions and produce salt efflorescences of epsomite ($MgSO_4.7H_2O$). Before knowing

Table 3. What does the term 'veil' mean?

Simple description	'Veil' means a whitish or greyish, tarnished aspect of the surface.
Different characterizations according to closer inspection and/or scientific analyses:	The veil is a *coating of the surface* by - dust - a powdery salt efflorescence (gypsum veils) - a very thin (semi-transparent) crust - etc. The veil is an *altered surface* caused by - decomposition (microcracking) of the binder - discoloration of pigments - etc. The veil is an *intermittent (ephemeral) phenomenon* caused by a porous and actually dried surface.

this, we characterized these dark spots in the maps as just "dark spots of humid aspect". Figure 3 shows a section of the graphic documentation we did there (Arnold *et al.*, 1986). The damages are distributed in a zone of about 0 - 3 m height on the Carolingian and Romanesque wall paintings. This zone has been affected by ground moisture and salt accumulations over the course of many centuries. After the restoration of 1950, the humidity regime in the walls changed drastically due to a new water discharge system and a heating system installed in the interior. As a consequence, the zone of active decay moved upwards. It was therefore necessary to distinguish between different damage generations (see legend in Figure 3), such as old pits (from detached paint particles, these pits had been retouched during the restoration, in 1950, so they must have been formed before that time) and recent pits, granular dis-aggregation, scaling of intonacos and repairs, and dark spots of humid aspect. The salt efflorescences observed were differentiated as fluffy efflorescence, bristly efflorescence, pustules, crusts, and powdery efflorescence. The distribution of the salts analysed from efflorescences (i.e. crystallized matter) is indicated by symbols on the same map. As a consequence of the detailed macroscopic differentiation of the efflorescence and of the analytical results, we could recognize the different vertical distributions of the different salt types. For instance, epsomite was present in the lower part and in the form of crusts only; sodium nitrate ($NaNO_3$) was in the upper part in the form of fluffy efflorescence; while gypsum and potassium nitrate (KNO_3) were present from the bottom to the top of the affected zone. By continued investigations on several other objects it became possible to recognize the typical vertical salt deposition in the zone of rising damp (Arnold and Zehnder, 1989, 1991; Zehnder, 1996).

Further issues when working on site are:

➢ Organize the information systematically. Principal categories to be distinguished are: (1) the materials themselves; (2) their condition, damage and other particular, current properties; (3) the environment, impacts, etc; and (4) interventions. It is recommended that this logical sequence be used as the basis to proceed, but not obstinately so.

➢ Distinguish between observations and assumptions. Even if this seems obvious, it is not always clear and too often ignored in practice.

Figure 1

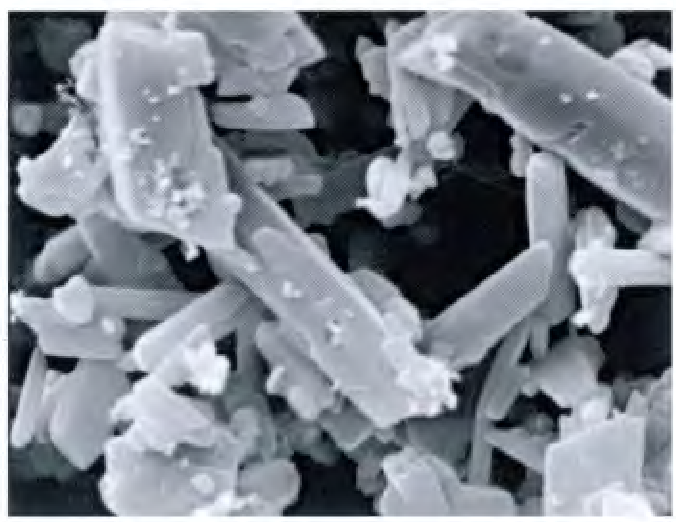

Figure 2

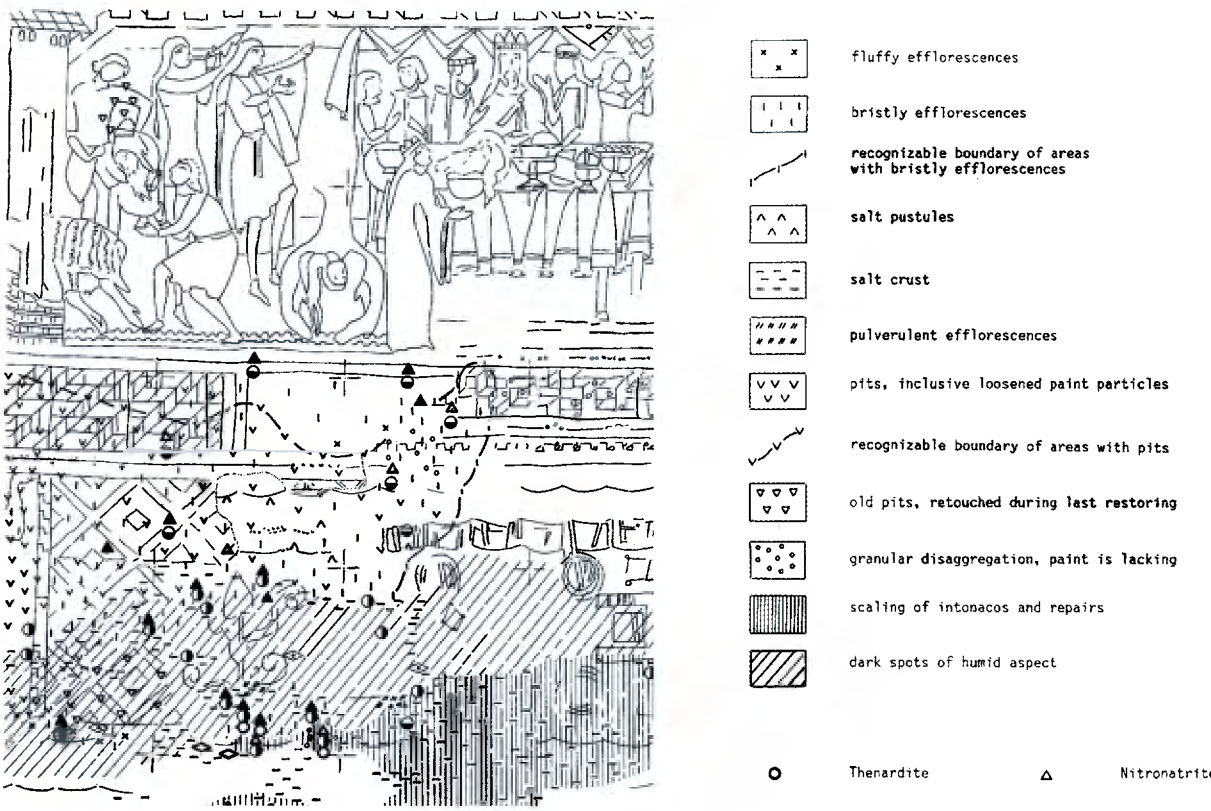
fluffy efflorescences
bristly efflorescences
recognizable boundary of areas with bristly efflorescences
salt pustules
salt crust
pulverulent efflorescences
pits, inclusive loosened paint particles
recognizable boundary of areas with pits
old pits, retouched during last restoring
granular disaggregation, paint is lacking
scaling of intonacos and repairs
dark spots of humid aspect
Thenardite
Nitronatrite

Figure 3

➢ Reflect the basic questions, yet remain open to new and alternative answers.

➢ Trace the 'hidden' relationships between the 'obvious' facts.

The last-named often needs time. For example, the damage assessment begins by identifying the various damage forms. In the end it should reveal a distinct pattern of the distribution, intensity, etc., of damage phenomena. This pattern is a new and most important piece of information. It leads to identification of the *damage situation*. This term defines the local complex of specific damage types that can be attributed to one or several, specific and local causes.

A crucial point is the cooperation of the different specialists involved, particularly between conservator-restorers and natural scientists. The different training and different methodological approaches lead to different interpretations of the same 'facts.' Thus, geologists might perceive specific damage on the work of art primarily as a *result of the weathering process* (weathering is the result of events occurring at a particular place, at certain times, under distinct conditions, with a certain velocity and with certain effects on the particular materials), and try to determine its evolution. In contrast, conservators are primarily confronted with localized *loss on a work of art*. They tend spontaneously to interpret damage as if it had developed recently and will progress rapidly. So they may overestimate the weathering dynamics and overlook the real processes. The great advantage of interdisciplinary dialogue on site is mutual learning from the other's specialized viewpoint.

As is evident from the example of the dark spots, measurements of physical properties and sampling of materials are indispensable for specific diagnoses, involving further investigations in the laboratory. However, such additional work is based on the particular findings on site in order to yield relevant information. Methodologies of tracing back, measuring and documenting decay processes are presented in various publications (e.g. Arnold, 1994, 1995; Arnold and Zehnder, 1989, 1991; Zehnder, 1996).

Laboratory investigations

Examinations of samples (by microscopy, chemical analysis, etc.) are standard scientific investigations, providing in-depth knowledge of the materials, techniques, state of preservation, environmental impacts, etc. It is always advantageous to proceed from the general inspection of the materials to sophisticated analysis in order to get a coherent overview of information, and not just a random assemblage of very accurate but isolated scientific results. This holds equally true for on-site observations: start with the whole, and then focus in on the significant parts.

Evaluation of data

The crude information must be evaluated and collated to form the essential message. This step is missing in documentation where the materials and the damage are appropriately documented, but which then jumps straight to interventions. Similarly, if some evaluation has been done but it is not appropriately reported it will never be comprehensible. The crucial questions that have to be asked and answered are:

➢ Are the damage phenomena active, and, if so, how fast do they progress?

➢ What is causing the damage?

➢ In consequence, what are the current and future risks?

Since the answers to these questions decide the urgency and directions of further actions, by such an approach we direct our attention away from the unthinking, reflex-action repair of damage towards long-term conservation and to what should be our aim: sustainable care.

CONCLUSION

Documentation must be seen as a coherent entity, systematically combining text, maps, photographs, scientific analyses, etc. It contains and delivers a specific message. This message should be clear, concise and as true as possible. The questions we keep in mind during the documentation process determine the final result. Documentation as a process is the medium by which we observe precisely (since it obliges us to reproduce our findings), reflect on and understand, in order to intervene appropriately.

The first issue of documentation is to achieve the base survey. Supplementary detailed documentation can then be effected more precisely.

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3
COSTING GRAPHIC DOCUMENTATION: HOW MUCH MONEY AND WHOSE TIME?

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ABSTRACT

Advances in technology have fuelled an escalation in the potential of graphic documentation, resulting in a concomitant rise in expectations. With rare exceptions, funding has not kept pace with these expectations, and conservators have bridged the gap by subsidizing documentation. Clear statements of objectives of the documentation and for the resulting level, accuracy, output and archiving requirements are needed. From these, resource implications can be determined, including the knowledge and skills required of the documentation specialist – who may well not be the conservator. Only when documentation requirements are realistically specified and transparently costed can appropriate funding be expected to be allocated.

KEYWORDS: *wall painting; documentation; funding; management.*

INTRODUCTION

Graphic documentation has evolved dramatically in only the last ten years. Although this transformation is partly a function of our documentation requirements, it is largely a response to developments in technology. The options for manipulating and presenting data evolve with each new version of software, and each improvement in processing speed. As a consequence, our expectations of graphic documentation have outstripped our resources and we seem to be struggling to bridge the 'resources gap'. This struggle is characterized by a disproportionate investment of our own time - in effect a subsidy. Clearly, this is unsatisfactory and a more viable approach would be to critically analyse our documentation requirements and then to set realistic, accurately costed objectives. For the purposes of the present discussion, and within the context of the documentation methods presented in the seminar, the assumption has been made that graphic documentation is computer-based.

SUBSIDIZING GRAPHIC DOCUMENTATION

We have persuaded ourselves – that is, conservation specialists – that documentation, most typically graphic documentation, is an essential part of any serious conservation programme, and we have been increasingly successful in persuading the non-specialists who control the funding of conservation programmes that documentation should be an integral component in planning and costing conservation. But we have not been successful enough; there is too often a gap between the standard of documentation demanded by the conservators and that that can be completed with the funding available. This gap is often bridged by the conservators themselves. Curiously, the consequence is that documentation remains the most significant component of any conservation programme, which is heavily subsidized by the conservators. The subsidy is usually time, but it is often a *lot* of time.

Why are we subsidizing documentation? Conservation is notoriously difficult to cost and to plan. There are far too many variables and unknowns. However carefully structured the methodology, however many preliminary investigations are undertaken, however much testing and assessment is carried out, there *always* remains the possibility that we will be surprised. Surprised by the recalcitrance of altered materials to respond to remedial treatments, surprised by conditions undetected by even the most thorough instrumental examinations. An ideal example is provided by the conservation of Piero della Francesca's *Legend of the True Cross* in Arezzo. It has been a model programme, with the most exhaustive, peer-reviewed preconservation diagnostic investigations of any wall painting conservation programme (Anon.,1989). Yet discovery midway through the project of the structural instability of the painted vault was completely unexpected. This is not a criticism, but rather a recognition of the complexity of our task. But do we face the same technical difficulties with anticipating the nature of the documentation required, the methods – and consequently time and resources – needed to collect, manipulate and present the data? If not, then why is documentation the step–daughter – or Cinderella? – of our conservation planning?

Perhaps the premise – that we heavily subsidize documentation – is not implicitly acceptable. It should therefore be tested. Not surprisingly, however, there is little in the conservation literature that specifically addresses this issue. There seems to be a tacit agreement that resource implications are ignored, that the very real constraints imposed on what is feasible are rarely specifically mentioned. Exceptionally, in a paper on preconservation documentation, Karl Ludwig Dasser (Fachhochschule Köln) broke ranks to emphasize the problem of conservators' subsidies:

> Finally, although funding problems are generally excluded from consideration at scientific colloquia, they are of primary significance and should be addressed. Conservators are well aware of how to undertake and document precise pretreatment examination, but the other project participants are not always persuaded of the necessity of such measures... [Therefore] many committed conservators prepare documentation virtually gratis, from a sense of responsibility toward the work of art (Dasser, 1991).

Although this assertion may strike many of us as self-evident, it must nonetheless be considered as unsubstantiated anecdotal evidence.

More reliable data was gathered directly from practitioners by Lorinda Wong (Courtauld Institute) in her research on condition recording of wall paintings (Wong, 1997). While her questionnaire (returned by 46 specialists in 18 countries) understandably focused primarily on technical aspects, some of the questions can be seen to relate to the issue of conservators' subsidies, or, more accurately, ultimate responsibility. The responses to question 6.1 – *Who is responsible for producing the finalized documentation?* – were very telling. In *all* responses, 'conservators' were considered to be responsible, and only eight of the respondents indicated that any *additional* specialists were involved. Of these eight, virtually all were institutional.

This suggests that the primary responsibility for documentation has been assumed by or devolved on conservators. The necessity for universal involvement of conservators in data *collection* – in which professional judgements must be made – is obvious. But in the prevailing technological context – dominated by increasingly complex computerization – the need for conservators to be responsible for data *manipulation* and *presentation* is far less obvious. Indeed, it could be argued that it is not an appropriate allocation of scarce and expensive resources, i.e. conservators. Moreover, the increasing complexity of documentation is symptomatic of the profession as a whole. *All* aspects of conservation are vastly more complex than they were only a decade ago. Take, for example, the proliferation of non-invasive diagnostic techniques, critical tools for a conservator to understand and use. Although their use typically involves other specialists, the role of the conservator in directing and interpreting the investigations is absolutely central and cannot be delegated. And this is only one example of the increasing skills and knowledge required of conservators.

Therefore, should we be committing a significant proportion of our time to mastering the rapidly developing tools of documentation and, still more worrying, to subsidizing the documentation component within conservation programmes? The short answer is no. But the longer and more sensible answer is that we must rationalize our efforts by critically analysing our documentation *requirements* – that is, not what is possible or desirable, but what is *necessary* – and by persuasively demonstrating the necessity for documentation and thereby forcefully arguing for appropriate funding to be put in place. In order to do this we must know what the *actual* costs are, costs that are currently concealed by our altruistic subsidies.

Such a seemingly negative view of the current state of documentation affairs cannot stand without reference to the considerable and successful efforts of colleagues to address the issue of the inordinate amount of time invested in data manipulation and presentation. The development and implementation of streamlined methods for collecting and entering data into AutoCAD by Giancarlo Buzzanca (Istituto Centrale) and Francesca Piqué (Getty Conservation Institute) – both reported in these proceedings – has dramatically reduced the time required, while simultaneously reducing the risk of introducing error at the data entry stage (Eppich and Piqué, 1999). Although the methods of scanning and positioning were devised for importing data into AutoCAD, they can also be used to save time and enhance accuracy in more conventional and accessible programmes, such as CorelDraw.

A word should be added about copyright and intellectual property, particularly in view of our subsidies. International charters and guidelines of professional bodies are curiously mute on these questions, a symptom of the relative infancy of our profession. With the increasing clamour for integration and accessibility of data, we should no longer ignore these issues. Integration means that one professional's work – which may well still be at the research stage – must be handed over to collaborators. Accessibility presumes that issues of copyright are clearly defined and observed, both of which are difficult to ensure in the electronic domain.

RATIONALIZING GRAPHIC DOCUMENTATION

In order to properly cost documentation it is first necessary to critically analyse what is required. Advances in technology offer us a bewildering choice of graphics programmes. However, these affect primarily the potential ways in which the data can be interrogated and presented rather than the nature of the data to be collected. A critical survey of the advantages and disadvantages of the various programmes for graphic documentation would be very welcome. Interestingly, apart from direct data-input, little has changed to improve the methods of actually *collecting* data.

Clearly, defining the objectives of the recording – the function of the documentation – is the essential first step. For example, diagnostic documentation, to define the nature and distribution of *patterns* of deterioration and undertaken as an essential preliminary for determining investigations to be carried out, may only require a very summary survey and a low level of accuracy. By contrast, surveys or condition recording intended for site management or for planning and costing remedial interventions may well require much greater detail. It may be argued that for monitoring of condition, graphic documentation (particularly if the basemap is a line drawing) is a very crude tool, and could only be effective if a high level of accuracy is achieved and the change occurs on a macro-scale.

Definition of the function of the documentation should then generate:

- the specific audience and therefore the output requirements;
- the level (scale, detail) of the recording;
- the accuracy required and any verification system needed; and
- storage and archiving requirements.

This is, of course, more easily said than done, and in practice there is a tendency to anticipate all of the potential functions of documentation by making a 'comprehensive' record. There are some good reasons for this, since access is almost always problematic; typically, scheduling of personnel and of scaffolding and the resulting disruption in building use must be done well in advance and often cannot be easily repeated. But this is not always the case, and there are similarly good reasons to resist the temptation to produce 'definitive' documentation at the outset of a programme. Among the more compelling is that understanding the painting is an iterative process, dependent on cycles of examination, observations, and formulation and testing of hypotheses.

COSTING GRAPHIC DOCUMENTATION

Accurate costing of documentation will depend on a number of interrelated factors, including those outlined above – level, accuracy, output and archiving – as well as the choice of graphics programme and the resource implications that each of these has. What, for example, are the resource implications of specifying a placement accuracy of, say, ± 1 cm compared to

± 3 cm? Or are we not explicit about the accuracy of our documentation? Do we simply assume the level of accuracy *implied* by the output? From this point of view, the use of line drawings as base maps automatically suggests a lesser degree of accuracy, given the considerable abstraction of the drawing itself. Moreover, it is far less readily verifiable than documentation overlaid onto a photographic base map.

And what of output? Or, more pertinently, accessibility and use of the documentation? Determination of the systems for inputting and accessing the data will dictate the resources needed: the skills and knowledge required of the personnel, and the processing time. Yet some of these systems have become so complex that we can hardly afford to use them. The most successful wall painting documentation system, successful in terms of the comprehensiveness and integration of the data, is that developed for the Piero conservation programme in Arezzo (see Casciu, this volume). It is stunning in the wealth of material included and will doubtless provide an unparalleled record of the conservation history of a single painting. Yet it is so complex that it requires a specially trained professional to use it, and is therefore not readily accessible to the conservators. This is an extreme case, but indicative of the trend toward hardware– and software-intensive systems requiring separate professional skills – those of a documentalist rather than a conservator.

Finally, hidden subsidies cannot continue. For adequately costing documentation we need some hard information on the time it actually takes and the skills required. Collecting this information from institutions may be relatively easy – though one suspects (or indeed knows) that even in an institutional context, midnight oil is burned over computers – but it is more critical to know what is happening in the private sector, where unrealistic expectations are surely putting unfair pressure on private conservators.

FUNDING GRAPHIC DOCUMENTATION

Wong attempted to gather data on funding for documentation, but it is not readily accessible; as a profession we seem reluctant to talk about money. However, for the massive conservation programme of the cupola of Florence Cathedral, 'indagini e rilievi' are reported as having received 21% of the overall budget (Acidini Luchinat and Dalla Negra, 1995), though it is not clear what proportion was for documentation. It was, nonetheless, a large sum since the aggregate amount approached the 29% devoted to the actual conservation. One assumes that a similar budgetary emphasis is put on documentation for comparable high-profile programmes – the Sistine Chapel, Arezzo, Dunhuang – but one can only assume.

The implication is that those responsible for the conservation were persuaded of the necessity for recording to the standard now set by these projects. Surely this is in part for the purposes of publication, but only in part. The mass of data collected could never be fully published and the explicit justification includes an obligation to provide a record both of the intervention and of the state of conservation of the object prior to treatment. Although this is an obligation that resonates internationally, and has permeated to even the most parochial of conservation authorities, it does not necessarily translate into an appropriate funding commitment.

It is therefore necessary for us to take the initiative: to argue cogently for the necessity of the undertaking documentation *to an appropriate level*, and to clearly and transparently cost the documentation, without subsidy.

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4

GRAPHIC DOCUMENTATION OF PAINTINGS IS MORE THAN A TECHNICAL REQUIREMENT FOR CONSERVATION

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ABSTRACT

The philosophy and techniques adopted in conservation of mural paintings in different countries cannot be the same, as they have to satisfy both cultural objectives and technical requirements. Different methods that have evolved and been adopted in documentation and conservation of mural painting during the last two decades by the UNESCO - Sri Lanka Cultural Triangle Project will be relevant to the ongoing painting conservation activities of many other countries. The methods used are simple and systematic in performance, and economical and adaptable to any situation without excessive reliance on high-tech methodology. In particular, the documentation processes carried out so far are not only technical documentation to help painting conservation but also help in preserving the artistic and cultural values of the painted heritage, and can also be used as a monitoring tool.
KEYWORDS: *mural painting; civilization; conservation approach; philosophy; technique; material heritage; cultural heritage.*

The creative arts – including mural paintings – produced by different civilizations often have deeper meanings, fulfilling varying requirements in different temporal and spatial contexts. Similarly, the conservation approach has to reflect the cultural philosophy and the technique used, simultaneously satisfying both cultural objectives and technical requirements. For example, in the same geographical and historical context, Muslim paintings in a mosque differ in their purpose from the paintings in a sultan's palace or a Buddhist temple.

The traditional Sanskrit term *chitra* in the South Asian region means both sculpture and painting. The traditional *shilpa* texts identify chitra under three categories: full sculpture, bas-relief and painting. All these three were done by the same artist and integrated together into a single composition using colour. In architectural contexts there was hardly any sculpture without plastering and painting, so it has been necessary to evolve a different methodology for conservation and documentation for conservation of such heritage.

In South Asia, especially in Sri Lanka and India, there are shilpa texts written on the craft of mural painting, complied from the 5th century AD onward. Most of these were written between the 9th and 13th centuries. In some of these books there are separate chapters on restoration, with identification of the cultural concepts and methodology. These descriptions even go into details, such as identifying the necessity of visually covering the monument or the object of restoration so that it is not seen by outsiders during the work. Restoration was an accepted phenomenon in the process of continuing the artistic and spiritual values of the cultural heritage. After restoration, the art object needed to be ceremonially and ritually introduced to the public. It was indicated that the restoration work was to be handled only by a master artist, and with great devotion and care.

Material heritage in art is thus synonymous with cultural heritage. This leads to a discussion of how important is the preservation and sustainability of the cultural heritage element in the technical processes of preserving the material heritage in paintings. There is no doubt that the conservation effort is to preserve the cultural heritage, using science and techniques evolved during the last few decades. The objective of this seminar is not to discuss the conservation of painting, but to discuss the documentation of mural paintings for conservation.

The art heritage of Sri Lanka is one of the most valued cultural treasures of the country, and has been continuously created and preserved, with examples from the 5th century AD until now. Paintings were created on plastered rock surfaces, walls, ceilings and on timber surfaces. Five of the seven World Heritage Sites of Sri Lanka – Sigiriya, Anuradhapura, Polonnaruwa, Dambulla and Kandy – have valuable paintings. The Rock Temple of Dambulla alone has more than 2 000 m^2 of mural paintings. The UNESCO Sri Lanka Project of the Cultural Triangle – ongoing for the last two decades – has evolved various methods for documentation of mural paintings for conservation purposes.

The methods evolved and adopted in the Sri Lankan context are relevant to other ongoing painting conservation activities elsewhere. Most of the methods used are simple and systematic in operation, economical, and adaptable to any situation without relying on high-tech methodology. Exchange of ideas would be of immense use to improve the current system in Sri Lanka.

This paper will present the involvement, and experience, contribution and achievements of different categories of persons, including traditional artists, conservators, conservation managers, photographers, etc., who were involved in conservation of paintings in the last 15 years of the UNESCO Project of the Cultural Triangle.

In addition to urban composition and architectural fabric, the paintings created by man constitute an important, impressive yet fragile component of heritage. As this forms not only a part of the architectural expression but is also physically supported by it, the task needs to be approached in an integrated, holistic manner, and not treating each aspect in isolation. The preservation of the mural painting is directly linked with the performance of the building. As most of the mural or architectural paintings in Sri Lanka are fragile, being found on clay plaster, the conservation objectives were twofold:

- to preserve the artistic composition and the expressions as they are found and seen today; and
- to physically consolidate and conserve the paintings and materials *in situ.*

Considering the magnitude and the importance of the project, it was necessary to identify the problems and issues in order to find suitable short- and long-term solutions. In designing the conservation project, the following issues were identified:

- the painting conservation programme needed to be considered from four aspects: immediate; urgent; short-term; and long-term approaches;
- build up a conservation team with trained personnel;
- financing;
- appropriate technology;
- time frame;
- management.

The paintings to be included for conservation under the project varied in many ways. The period of production was found to be from the 5th to the 20th centuries. All were tempera paintings, most on clay plaster with a clay or lime paint-receiving layer, and some on lime plaster. Paintings were found on undulating rock surfaces, rock ceilings, masonry walls, timber ceilings, etc. Therefore the documentation methodology had to be adaptable, capable of being modified to satisfy each situation. Some paintings dealt with were in good condition, some were decayed, parts lost and in fragile condition. Most of the paintings were sophisticated, with small, detailed compositions. The rest were simple, uncomplicated and larger, with less refined figures and decorations. Considering all these factors, the project decided to focus on both objectives simultaneously: document the artistic composition and to proceed with scientific conservation of the paintings.

In order to have a full-size record of the as-found artistic composition, all paintings were systematically copied in oil paints on canvas. This approach appeared laborious and extravagant, but in retrospect is considered a success story. The project was very fortunate to find three groups of trained, dedicated traditional artists to whom to delegate the task. Their instructions were to document exactly what was found at that time: lost parts, cracks, etc., were to be left as is; colours were to exactly match the original. No additions to the existing paintings were to be made. Some special places were re-documented by using the same copying method after cleaning.

During the copying process, the artists were faced with many issues. It was necessary to get a good detail tracing of the painting without applying any pressure on the plaster or the pigment layer. For this, large acetate sheets were used to obtain total transparency. Outlines were drawn with a thin brush using brown watercolour. The sheets were very light and carefully pasted onto the wall using boiled rice grains because no pigments are removed with this adhesive. The line drawings made were transferred onto canvas through tracing paper, and colour copying was done *in situ*. Because of the artists' skill and careful effort, the products were very good.

All the overlays were numbered, catalogued and carefully stored in the painting museum. We are now in the process of publishing all the line drawings for posterity. All copies on canvas are either mounted on frames or individually rolled if large, and preserved in the National Painting Museum.

In addition to this time-consuming copying, specially trained photographers were employed to carry out a complete, systematic documentation of all painted surfaces, both as slides and as photographic prints. The slides and negatives are preserved in humidity and temperature-controlled laboratories of the Central Cultural Fund. Both these copying processes – photography and painting – were implemented in parallel to the technical documentation done for the scientific conservation of the paintings.

When the project started in 1982 it was found that only a few technicians in the Department of Archaeology were engaged in painting conservation, under the Commissioner, a chemist who was specialized in conservation of paintings. The group was headed by one conservator trained at ICCROM. Due the shortage of trained personnel, the project recruited ten university graduates from the fields of chemistry and fine arts. A practical training programme was launched at Dambulla for the new recruits, but was only partially successful. It was therefore decided to send them to ICCROM for training. Since then it has fortunately been possible to send one or two conservators for training at ICCROM annually, as well as conservators trained at the Sri Lanka Postgraduate Institute of Archaeology.

Two groups, one based in Dambulla and the other in Kandy carried out painting conservation in the Cultural Triangle. The first steps were the graphic documentation required for conservation and research. As there were a large number of panel, wall, ceiling and sculpture compositions, these were numbered in a clockwise and bottom-up direction on an architectural plan, and standardized for all conservation work. Each wall of interest was again subdivided into a 50 cm 30 cm grid, and these grids were numbered using vertical-horizontal coordinates for identification purposes. This became the reference key for all documentation and all steps in the conservation process, and also for payments to the copyists. Each module was numbered and given a "Bed Ticket" [clinical form] with all information and diagnosis.

These grids were marked in front of the painted wall by using threads fitted on to a frame. The grids were individually documented graphically, and photographed for proper identification. The size of the grid was changed and enlarged depending on the size and detail of a painting. Conservators carried out graphic documentation on each grid based on the ICCROM method, but in the process they have modified the method to satisfy the situational requirements. This graphic recording was done in pencil on one sheet, giving all symbolic identifications. Later it was found that the information gathered was too crowded and may not be easy to understand for future reference. Hence the information was transferred onto separate base maps in the laboratory, according to different categories. This made the graphic information specific and clear for easy reference in the future. It formed a detailed recording for future conservators and researchers within different categories, such as physical damage to plaster, paint-receiving layer, condition of the pigment layer, early interventions, etc.

All the conservation work was done under supervision and reviewed periodically. In-service training and workshops were conducted on both documentation and conservation.

The most important thing was considered to be to catalogue and preserve this information and make it available, with easy access. All documentation on the paintings and related interventions is preserved at the Painting Conservation Laboratory at Dambulla. The line drawings on acetate overlays and the photographic documentation are in the process of being printed for research and art appreciation. Currently the project is studying the possibilities of computerizing the available documentation of the painted heritage of Sri Lanka, covering five World Heritage Sites. The documentation process that has been carried out so far is not only technical documentation to help in painting conservation, but also a record to help preserve the artistic and cultural values of the painted heritage, and also to be used as a monitoring tool.

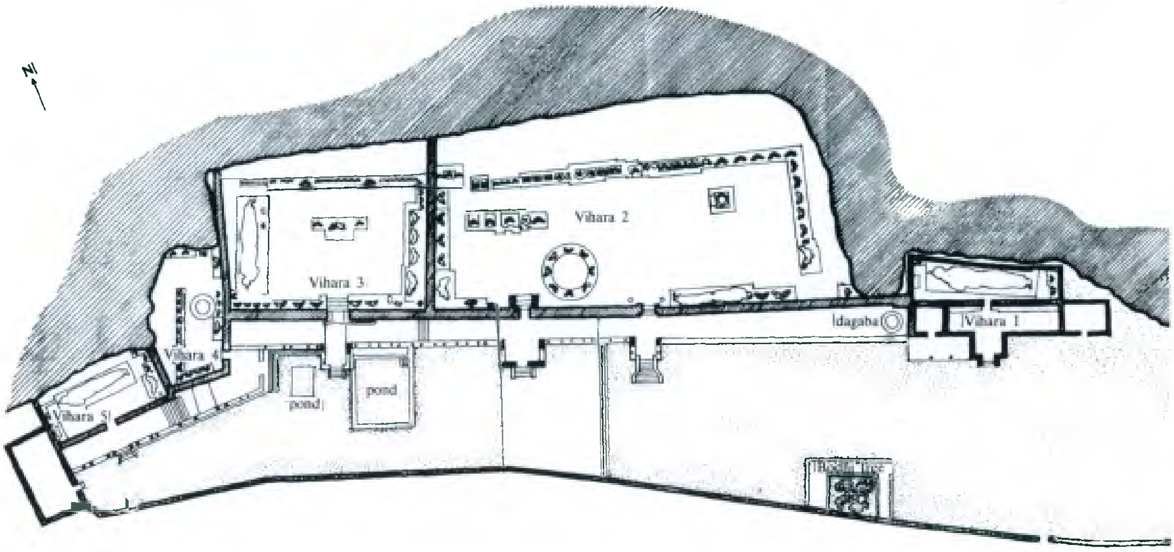

Figure 1. Lay out plan of the Cave Temple of Dambulla.

Figure 2. Exterior View of the Dambulla Cave Temple.

Figure 3. Paintings have integrated the sculpture with background.

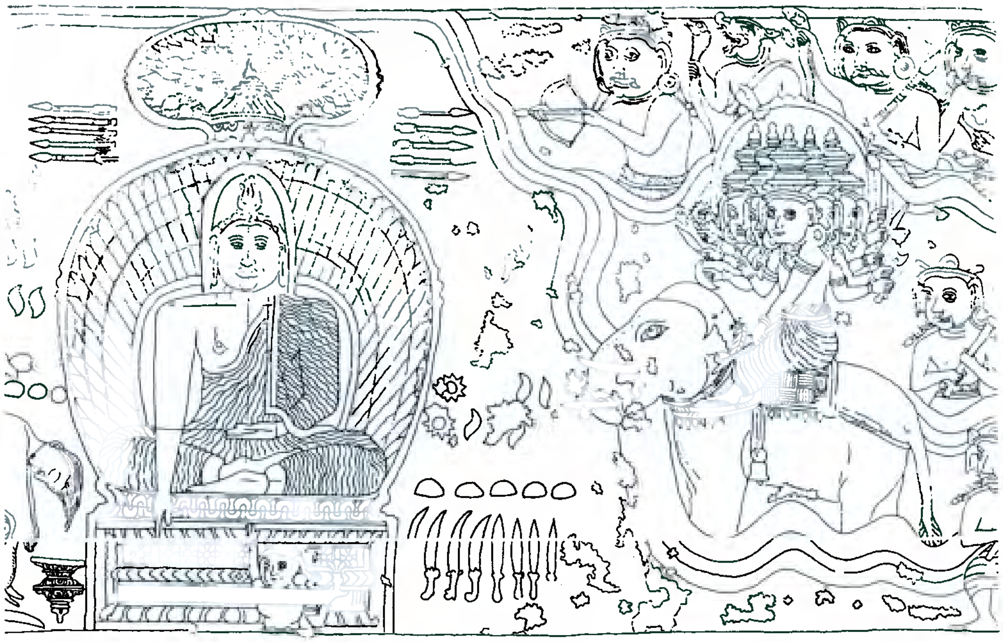

Figure 4. The Great Enlightenment and the battle with Mara, Wall painting, Gangarama Vihara, Kandy.

Figure 5. The marriage of Prince Siddhartha to Yasodhara, Wall painting, Gangarama Vihara, Kandy.

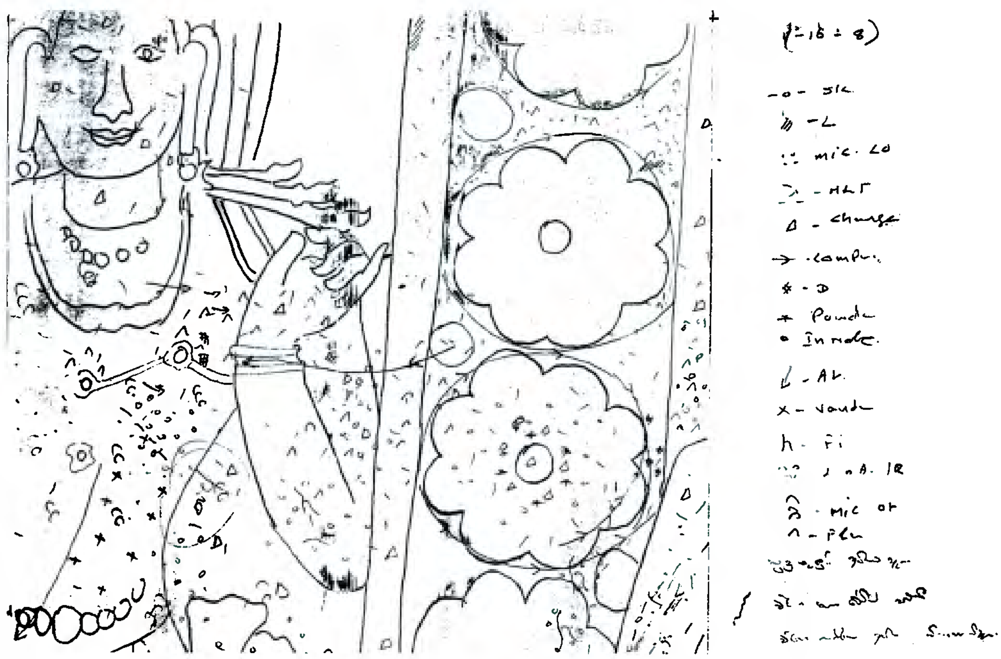

Figure 6. Basic Pencil drawing prepared at the site indicating all relevant information of the painting.

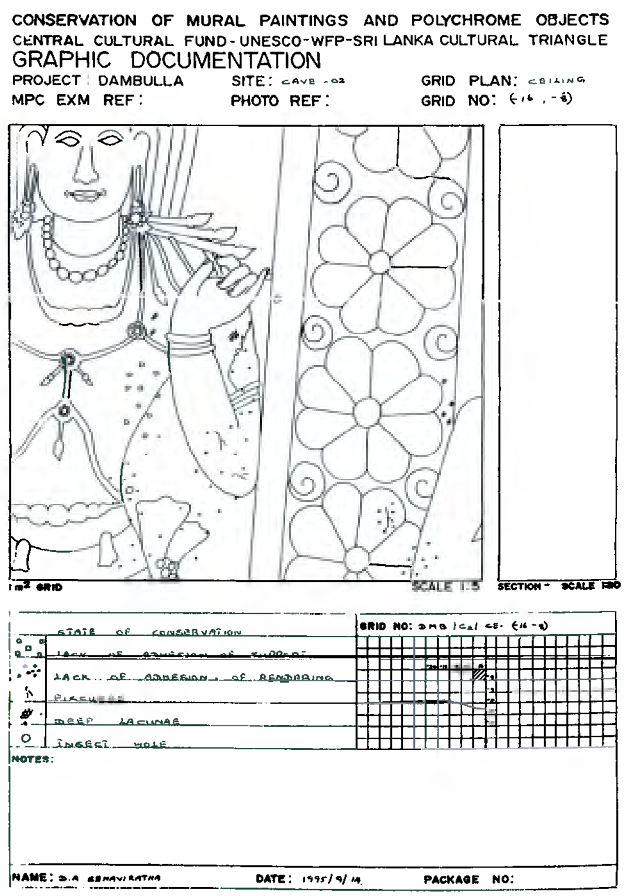

Figure 7. Example of final recording sheet regarding the state of conservation.

5
A PROTOCOL FOR GRAPHIC DOCUMENTATION

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ABSTRACT

The experience gained from several types of conservation projects with various objectives and partners, and in different conditions and geographical areas, has led to the development of a protocol for managing graphic documentation that may be usefully applied to the graphic recording requirements of similar projects. The protocol presented here is divided into three phases: planning, data collection and data organization. It seeks to provide a framework to be used under variable circumstances and situations of fieldwork.

The guiding principle behind this protocol is that the project's objectives direct all decision making. This principle carries over to the graphic documentation choices to create a balance between the best possible results, the resources available, and sustainability in the country of application. Choices include the accuracy required, the level of recording to be done, and the methods and techniques to be used. The protocol is a process for determining the most efficient and accurate course of action to follow while respecting the needs of the project.

***KEYWORDS:** graphic recording; documentation; base maps; glossary; legend.*

INTRODUCTION

Documentation has in recent years become a fundamental component of the professional practice of conservation. Documentation is the systematic collection, organization, and access to data and documents from investigation, treatment, and monitoring. Documentation is the body of information acquired in various formats over time as the project unfolds. Part of the body of information making up documentation is in graphic form. Graphic documentation is a record of phenomena or other data presented as superimposed symbols, patterns or colours over an image or base map representing the object (ref. terms used in the GraDoc seminar).

The object of this paper is to describe a protocol for the management and production of graphic documentation that was developed at the Getty Conservation Institute (GCI) as a result of experience gained through various recent field projects involving the assessment of wall paintings, mosaics and other types of decorated surfaces: all surfaces that can be considered as two-dimensional for the purposes of graphic recording. Graphic recording has been a component of the assessment phase of these projects and, for the projects that included the implementation of conservation, of the treatment documentation and long-term monitoring.

After planning for and conducting graphic documentation on several projects with different partners and under varying conditions (see Table 1), it became clear that a management protocol could be generally applied to all, regardless of the substrate or situation. While each project had different requirements and resources – elements that influence the decisions about how the project is carried out – the same protocol served as a management framework for graphic recording.

Table 1. GCI projects through which the protocol has been developed, and the graphic documentation undertaken.

Table 1. GCI projects through which the protocol has been developed, and the graphic documentation undertaken.

Project	Location	Objectives
8th C. wall painting Tang Dynasty Buddhist grotto	Mogao, Gansu province, China	Training Condition assessment Guide scientific research and investigation Identification of causes of decay Development of conservation plan Treatment documentation Dissemination Long-term monitoring
16th C. wall painting *Life of St. John the Baptist* by Filippo Paladini	Valletta, Malta	Training Condition assessment Development of conservation plan Treatment documentation Dissemination
20th C. wall painting *Pan American Unity* by Diego Rivera	San Francisco, California, USA	Condition assessment
20th C. wall painting *America Tropical* by David Alfaro Siqueiros	Los Angeles, California, USA	Condition assessment Dissemination Long-term monitoring
14th C. wall mosaic in St Vitus Cathedral *Last Judgement*	Prague, Czech Republic	Condition assessment Treatment documentation Dissemination Long-term monitoring
1st C. AD floor mosaic in Roman villa *Maison de la Cascade*	Utica, Tunisia	Training Condition assessment Identification of causes of decay Development of conservation plan Treatment documentation Dissemination Long-term monitoring
8th C. floor mosaic in Umayyad Palace	Horvat Minnim, Israel	Condition assessment Guide scientific research and investigation Identification of causes of decay Development of conservation plan Long-term monitoring
8th C. Byzantine floor mosaic in Kyria Maria Monastery	Bet She'an, Israel	Condition assessment Identification of causes of decay Dissemination Long-term monitoring
8th C. Byzantine floor mosaic in public and private residences	Caesarea, Israel	Condition assessment Guide scientific research and investigation Dissemination Monitoring during test
19th C. polychrome bas-reliefs in Royal Palaces	Abomey, Republic of Benin	Training Condition assessment Identification of causes of decay Development of conservation plan Treatment documentation Dissemination Long-term monitoring

Types of graphic documentation

Throughout a conservation project, graphic documentation is used to map several kinds of information. Typically graphic documentation is done during the condition assessment, then to record interventions, and finally as part of long-term maintenance and monitoring (Wong, 1997).

Condition assessment

Condition assessment is an essential component of a conservation project as it provides the basis of knowledge for the development of a conservation plan. Various aspects of a wall painting (or other decorated surface) are examined to lead to an accurate understanding of the present situation. These include the types of decay and their distribution, the presence of previous interventions, and the evidence of painting technique. The information gained from this examination is typically recorded in photographic, written and graphic form.

In condition assessment, graphic methods are used to record not only the types and extent of existing decay, but also to map differences between present and past condition when comparing historical photographs with the current situation. Typically, the latter is done to identify and distinguish active decay from decay that was caused in the past and is no longer active.

Condition assessment guides the identification of needs and priorities for investigation and treatment planning. Additionally, the conservators gain a valuable familiarity with and understanding of the art while studying and recording the various features. Assessing the type, extent and location of damage is crucial to the understanding both of the processes and causes of decay and the needs for specific investigations. Moreover, this rigorous examination may – if the relevant information is available – reveal the efficacy or failure of methods and materials from previous interventions.

The conclusions drawn from condition assessment support the project cost analysis and guide the setting of priorities for the best use of resources. Condition recording may also serve to disseminate information within the project team, to support fund raising, outreach and development of cooperative projects, and, later, for publication. As part of the condition assessment, graphic condition recording, together with photographic survey, will remain key documents for future comparison and evaluation of changes as part of long-term monitoring.

Treatment recording

Treatment carried out on an object should be recorded in graphic, photographic and written form. The treatment record is typically correlated to the condition record, since specific interventions are normally conducted on corresponding areas of deterioration. When layering graphic information, the mapping of treatment is typically recorded on new layers so that it can overlay the graphic condition records. Graphic treatment recording also functions as a management tool, allowing the conservator to follow and check on the progress of the intervention. The final treatment record indicating the locations, materials and methods used will be valuable for planning future work on the object and will facilitate evaluation of the long-term performance of the treatment.

Locations of test areas, probe placement, sampling etc.

This category includes various other information that may be usefully recorded in graphic form. When combined with condition records, graphic recording of treatment testing allows immediate comparison for assessing how representative the test area may be, the distribution and extent of the phenomenon for which testing was undertaken, and so on. When samples are collected for scientific investigation, their locations should be indicated graphically in conjunction with written and photographic documentation. In addition, analysis may result in the clarification of a previously recorded condition. For example, if the condition record indicates 'white efflorescence' and through analysis it is characterized as a specific salt, then the graphic recording can be modified to reflect this, thus simultaneously indicating the sample locations and the distribution of the salt. Similarly, the location of monitoring probes should be indicated graphically to facilitate interpretation of the data.

When digital tools are used for graphic documentation, there is the further potential of correlation of graphic information with databases. For example, results of analysis or environmental monitoring (such as temperature and relative humidity distribution) can be linked to graphic records.

Monitoring and maintenance
Monitoring should be an essential component of any long-term strategy for preserving an object. The artefact should be examined at regular intervals (based on the predicted rate of change). Graphic documentation is very useful in identifying and describing variations in the condition of the object and to record any maintenance interventions performed.

ROLE OF THE PROTOCOL AND THE PURPOSES OF ITS COMPONENTS

As in any process or activity, it can be very useful to have a protocol to follow, with clearly defined procedures and steps. While each project presents different situations, the protocol provides direction for achieving the desired results.

The protocol is also a tool for selecting options and making decisions. The typical issues facing the conservators while preparing for graphic documentation are:

- What to record?
- What level of detail and accuracy to use?
- How much time will it take?
- How many conservators are needed?
- Are the documentation technologies chosen and the resulting records sustainable under local conditions?

Typically these questions are asked to find the best combination among the goals "appropriate", "fast" and "affordable." They address the dilemma of finding a balance between a very accurate, complete and beautifully presented graphic record, versus the best use of the available resources (human and financial) for the project.

This protocol has also proven useful in the transition to digital forms. In the past few years at the GCI it has become necessary to have a least some of the graphic records in digital form for study, publication and dissemination of the results. This protocol provides a structure for identifying when it is best to translate graphic records into the digital domain. In the GCI's recent field projects, graphic documentation on site was organized and conducted in a way that facilitates transfer to digital form as required (Eppich and Piqué, 1999).

PROTOCOL FOR GRAPHIC DOCUMENTATION

The process of graphic documentation is divided into three phases, starting with planning, followed by data collection, and then data organization. In the following sections, each phase is described, with its component parts. Table 2 shows the overall management structure of graphic recording and indicates whether the component is typically carried out primarily in the office or in the field. This distinction has been made considering that work in the field is usually more expensive and difficult. This protocol has been developed on the premise of reducing work in the field and limiting it to the operations that can only be conducted in the field.

Planning (Step 1)
The planning phase is crucial as it involves making decisions that will affect all the other steps of graphic documentation. This phase includes the following components:

- Definition of objectives – linked or related to the overall objectives of the project.
- Definition of the recording method, e. g. tools, selection of base maps, etc.
- Definition and listing of elements to be recorded, including preparation of a legend and visual glossary.
- Practical preparation for the field.

Table 2. Structure of graphic recording process

	Phase	Where
1.	PLANNING	
1.1	Definition of the objectives	OFFICE
1.2	Definition of recording methods	OFFICE
1.3	Definition of elements to be graphically recorded	FIELD & OFFICE
1.4	Practical preparation for the field	OFFICE & FIELD
2.	DATA COLLECTION	
2.1	Graphic recording of elements	FIELD
2.2	Review of legend and visual glossary	FIELD & OFFICE
2.3	Control of graphic records	FIELD & OFFICE
3.	DATA ORGANIZATION	
3.1	Editing of graphic information	OFFICE
3.2	Presentation of graphic information	OFFICE
3.3	Storage of graphic record	OFFICE

Definition of objectives (Step 1.1)
The first operation is the definition of the objectives of the graphic recording. The team must define why graphic recording is necessary, how it will be used, and whether digital output will be required. For example, is it to be used for monitoring, or for condition assessment with a view toward development of a conservation plan, or both? Often there are several objectives that will guide decisions as to which techniques should be applied and what level of accuracy will be required (see Table 1). For example, if the graphic record is to be used for monitoring, it is important that the conservation conditions be documented as accurately as feasible. However, if the graphic record will serve to provide an overview of the general distribution of damage, then the degree of accuracy required will be lower.

Identification of the potential uses of graphic recording is limited by the fact that the work has just begun and it is not possible to foresee all future needs of the project. Generally, it is advisable to consider a broad use so that a lot of information is recorded. However, this must be balanced against available resources. Graphic documentation can easily become an enormous task and it is essential that the reasons for it – and any limitations imposed – be stated clearly at the outset.

Definition of the recording method (Step 1.2)
The recording method is chosen based on the objectives determined for the graphic documentation and the resources available. Recording can be accomplished using techniques ranging from the traditional use of coloured pencils on paper, to direct on-site recording on a laptop computer. However, experience so far indicates that direct digital recording is feasible only under limited, protected conditions.

Traditionally, graphic documentation is carried out by hand drawing on transparent sheets placed over the base map. Alternatively, the graphic recording can be marked directly on copies of the base map. Each element recorded is differentiated either by a specific colour, symbol or pattern, and this is explained in the legend included in the record.

Direct digital recording is an alternative to the traditional method and is done using computer and software to create digital drawings on layers corresponding to the traditional transparencies. Sometimes it is much harder to draw with a mouse; to improve this the mouse can be replaced by a 'digital pen' in pentop computers (which permits direct tracing on screen) or by using a graphics tablet. Additional problems are linked to the fact that software may not be user-friendly. Customized versions of software suites have been created so that conservators can more easily use them in the field (Buzzanca, 2000).

Recording tools, such as coloured pencils, markers, paper or transparencies, must be selected based on what will be most efficient and practical for use in the field, what will provide archival longevity (assuming the manual record is to be preserved), and what is available locally. For example, in very hot climates some markers tend to dry very rapidly and it is easier to use coloured pencils. However, these do not mark transparencies and therefore it is necessary to have multiple copies of the base map on paper. Archival longevity may not be necessary for working copies made on site when the intention is to discard them after editing and verification of the documentation. In some instances, however, the manually recorded documentation made on site remains the original and sole product of the project, and archival longevity must be considered.

One of the choices to be made is the type of base map on which data will be graphically recorded or superimposed. Typically, this is a photograph or a line drawing representing the surface under study. Line drawings can be made manually *in situ*, drawn or traced from a photograph or plotted from a photogrammetric survey. Obviously, the accuracy will vary greatly among these. Similarly, photographs can have an extremely variable accuracy, ranging from space orthophotos and rectified photographs, to traditional photographs of the surface. When possible, a photograph is used as a base map in the data collection phase because information to be recorded can be placed with greater accuracy. Subsequently, in the presentation of the data, a line drawing may also be used as base map if it makes understanding and interpretation of the graphic information easier. Photographic documentation is a normal component of a conservation project and when feasible, the photographic survey should be completed prior to the graphic documentation, thus allowing copies of the photographs to be used as base maps.

The accuracy of the base map must also be taken in consideration. For example, when using a photographic base map, the team must determine how many photographs will be necessary to render the area with the proper resolution, given the extent of the surface to be recorded and the detail and accuracy required. In determining the type and accuracy of the base map, it is important to keep in mind that the graphic documentation cannot have a higher accuracy than the base map over which it is recorded. The accuracy of the base map sets the limit to the accuracy of the graphic record.

In preparation for fieldwork, for practical reasons, the base map needs to be divided into manageable sections. The scale of the base map used for recording also influences the accuracy of the record. For example, a base map of a scale 1:5 can be used to record detailed features in a very accurate way, while general conditions can be graphically described on a base map of a scale 1:20. For example, the location of *giornate* or *pontate* can be recorded on scale 1:20, while a detailed piece of information – such as the location of retouching *a secco* – may need to be recorded on a base map at a scale of 1:5.

Typically, during the planning phase it may not be entirely clear what is the best scale for recording and it is useful to test this with base maps at various scales to record different elements requiring different levels of accuracy. When the base map is a photograph in digital form, scaling is very simple. Hard copies of base maps at different scales can be produced as the need arises in the field. Graphic documentation can begin at an intermediate scale, for example 1:15. During the examination the conservation team may identify areas to be recorded with greater accuracy and print specific sections of the base map in a larger scale, e.g. 1:5. When the base map is in digital form it is very easy, even in the field, to produce base map sections at different scales. Likewise, enlarged photocopies can be used, but with less flexibility and with loss of quality with each "generation" of copy.

Available historical records representing the paintings – such as drawings, watercolours or photographs – should be considered and evaluated for use as base maps. These have the advantage, especially when there are time and/or budget constraints, of being immediately available for use. However, being historical documents they may not represent the current situation or give complete coverage of the area under study. Base maps can be produced from this kind of historical material, e.g. from extant black and white photographs, by photocopying the original to produce a lighter version on paper. It is advantageous to have a lighter version, particularly when recording is done directly on the photocopy.

When the decision has been made to record directly in digital form, then the base maps need to be produced as digital files. The options are varied: photographs can be digitized, or digital cameras can be used to make electronic base maps ready for use. For the practicality of fieldwork, the size of the resulting electronic file must be determined in relation to the accuracy required and the hardware available. Once the resolution of the image has been determined, transforming the photograph to black and white helps reduce the electronic image file size while increasing the legibility of the overlaid data. It is essential to the success of the recording work to have manageable digital file sizes for the portable computers used in the field.

The selection of the recording method must take into consideration the availability of resources and the technical skills of the conservators and technicians carrying out the graphic recording, as well as the level of precision required and future use and needs for reproducibility of the data. Additionally, the sustainability in the country where the work is carried out must be weighed. Although one of the objectives of GCI projects is to introduce new technology, this must be sustainable once the project is completed. For example, in the Mogao project in China all the graphic data is in digital form at the Dunhuang Academy where there is the necessary hardware and software, as well as a person in charge of updating the information. In countries where computers are not readily available, and even photography may be difficult, graphic documentation can be done using photocopies of photographs and coloured pencils. In Tunisia, for example, graphic condition recording has been done over base maps made by photocopying photographs of the mosaics from a publication. Even though these were taken some 20 years ago and were not taken perpendicular to the mosaic surface, therefore having a slightly distorted perspective, they adequately served the purpose of a base map.

Definition of the elements to be graphically recorded (Step 1.3)
Another important component of the planning phase is the identification of the elements to be recorded. The conservation team, usually during a preliminary examination, inspects the object and creates a list of the elements that should be recorded. This list typically includes information on original technique, type of damage, previous interventions, etc. It should be complemented by a written and visual description, such as a photograph or diagram for each phenomenon or element described as well as a corresponding graphic symbol and/or colour to be used during data collection. In a digital environment, one digital layer is created for each element. This written and visual description – the visual glossary – is very important to guide a team of conservators doing graphic documentation and to ensure consistency in interpretation and recording. It is essential that the team that will carry out the graphic recording is also involved in the preparation of this document, and that there is agreement on its contents. In working with partners, it is important to adopt the partner's existing terminology insofar as possible, complementing it with a written description and a photographic representation of the phenomenon.

The preparation of a visual glossary requires effort, but has proven essential not only to provide consistency in recording but also as a tool for discussion and presentation of the results to project partners and funding institutions. When possible, the terminology and definitions of elements are adapted from existing glossaries prepared for similar projects. However, it is necessary to consider and finalize a glossary and terminology case by case.

Finally, as described in the data collection phase below, it is important to keep in mind that the list of elements to be recorded is an evolving document that needs to be re-evaluated and revised as the project progresses and as the conservators gain familiarity with the material under study. Graphic documentation should complement the photographic documentation. Elements that are clearly visible in a photographic base map may not need to be recorded in the field, thus avoiding that additional expense. For example, lacunae are typically visible in photographs and may often be included in the graphic record at a later stage by tracing directly from the photograph.

Practical preparation for the field (Step 1.4)
The planning phase concludes with preparation for data collection in the field. This includes assembly of photographs or drawings to create base maps, production of base maps in sections, acquisition of necessary recording tools (pens, paper, overlays, clipboards, etc.), preparation of the visual glossary, and, if the work is planned in digital form, loading of software and base maps on computers. It is prudent to take copies of all software to the field.

Data collection (Step 2)
The data collection phase includes the following components:

- Graphic recording of elements.
- Review of legend and visual glossary.
- Control of graphic records.

Graphic recording of elements (Step 2.1)
During this phase the conservation team thoroughly examines the object and records the type, location, and extent of the elements identified in the planning phase. To manage this, progress should be recorded on a general plan of the whole area that also indicates the various base map sections. The glossary and legend prepared in the planning phase are tools that aid the objectivity of data collection and the selection and use of graphic symbols. If the recording is made on paper or transparency, the legend that identifies the graphic symbols must be included on the same sheet on which the information is recorded, making each sheet self-explanatory. If recording is made directly on a computer, information of a particular type must be entered on the specific layer devoted to that category, as created in the planning phase.

Review of legend and visual glossary (Step 2.2)
After a certain period of careful examination of the surface, it is important that the conservation team review the list of elements being recorded. For example, an element may have been found to have two manifestations that should be graphically differentiated. In contrast, it may be found that an element does not need to be recorded graphically. For example, when a phenomenon occurs consistently in particular areas of the surface, the conservator may decide that its distribution can be adequately described in written form and it is not

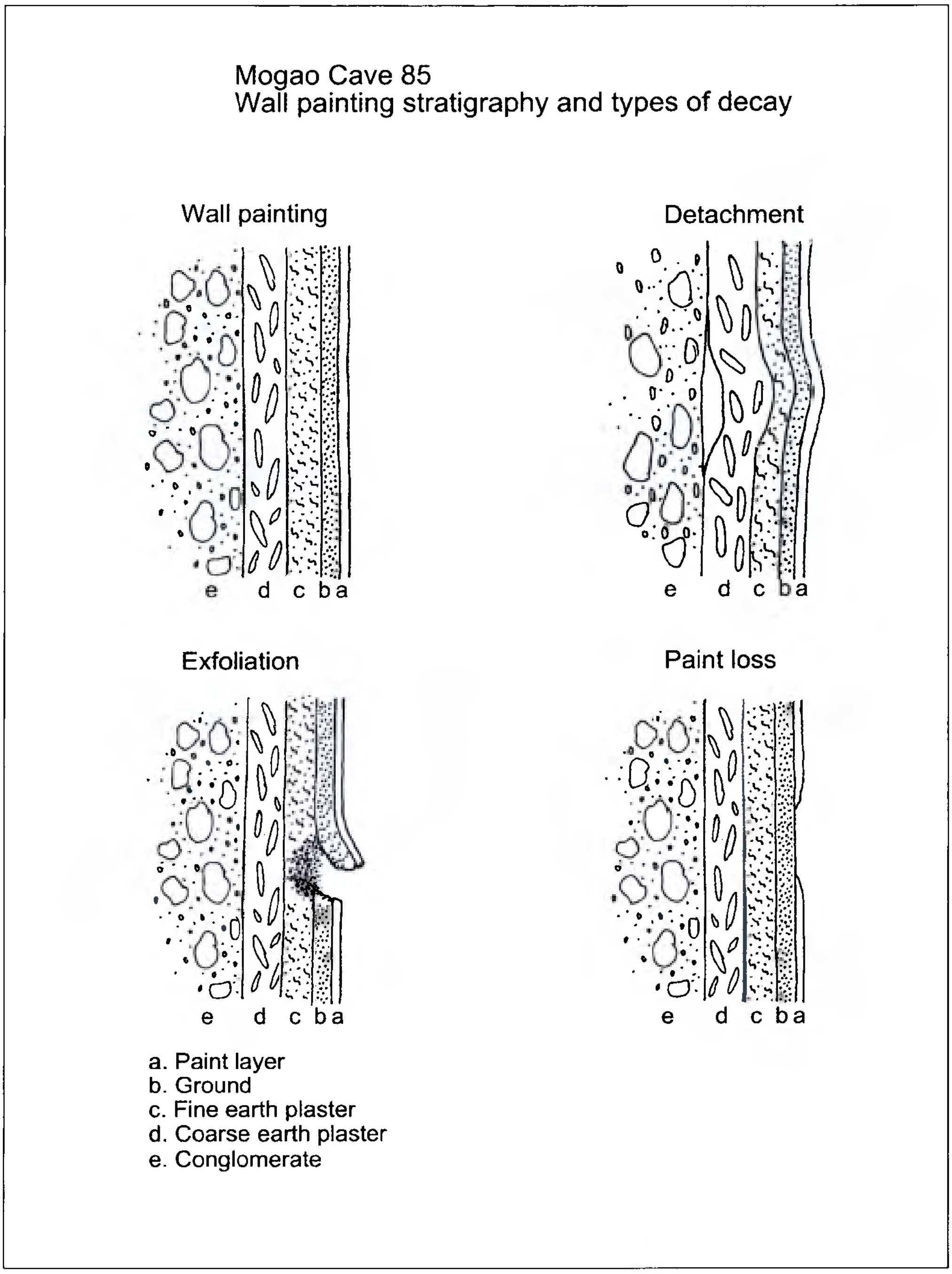
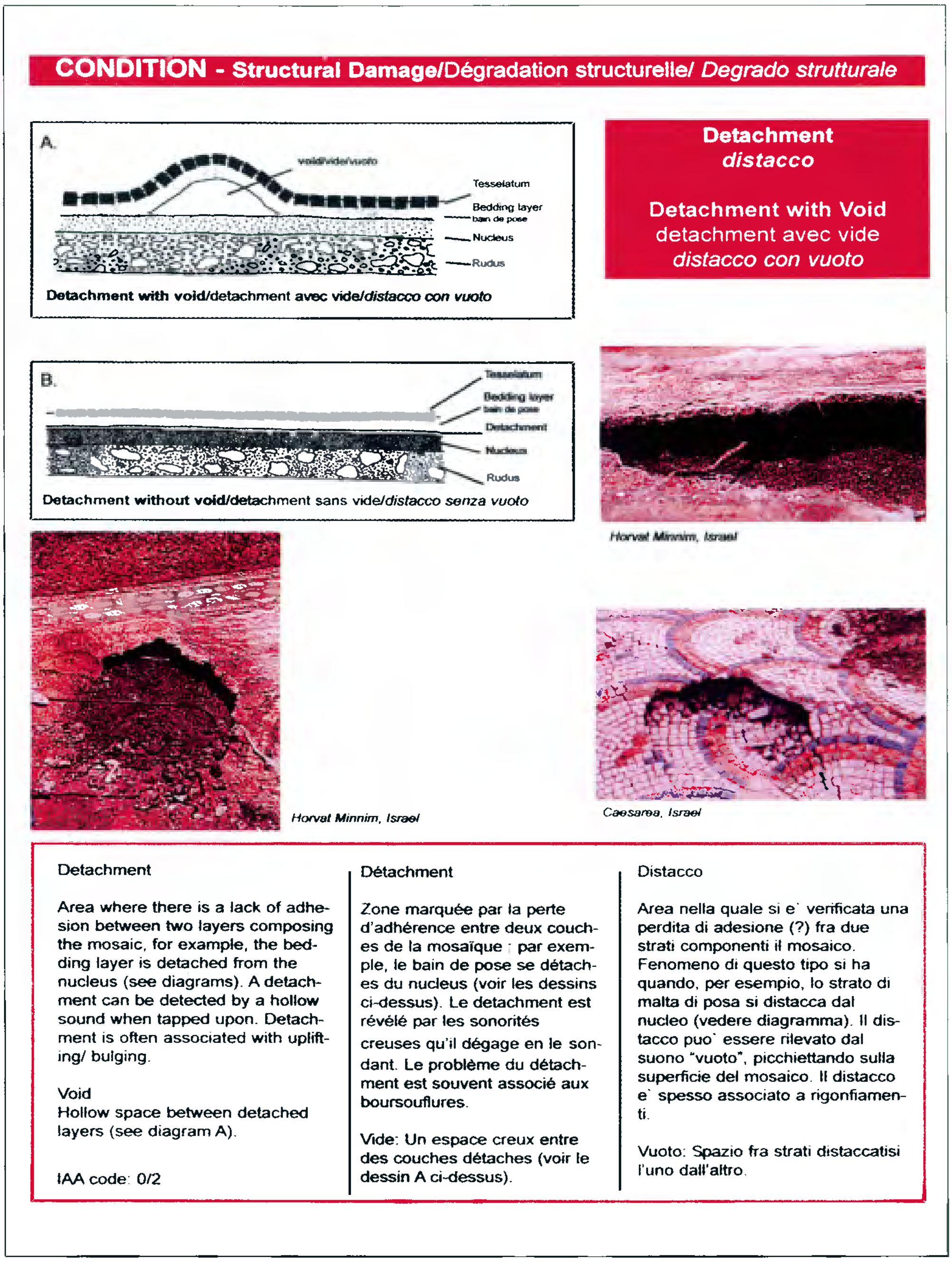


Figure 1. Example of visual glossary developed for the project of conservation of the Tang Dynasty wall paintings in Cave 85 at Mogao, China.


CONDITION - Structural Damage/Dégradation structurelle/ *Degrado strutturale*

Detachment
distacco

Detachment with Void
detachment avec vide
distacco con vuoto

Horvat Minnim, Israel

Horvat Minnim, Israel

Caesarea, Israel

Detachment

Area where there is a lack of adhesion between two layers composing the mosaic, for example, the bedding layer is detached from the nucleus (see diagrams). A detachment can be detected by a hollow sound when tapped upon. Detachment is often associated with uplifting/ bulging.

Void
Hollow space between detached layers (see diagram A).

IAA code: 0/2

Détachment

Zone marquée par la perte d'adhérence entre deux couches de la mosaïque : par exemple, le bain de pose se détaches du nucleus (voir les dessins ci-dessus). Le detachment est révélé par les sonorités creuses qu'il dégage en le sondant. Le problème du détachment est souvent associé aux boursouflures.

Vide: Un espace creux entre des couches détaches (voir le dessin A ci-dessus).

Distacco

Area nella quale si e` verificata una perdita di adesione (?) fra due strati componenti il mosaico. Fenomeno di questo tipo si ha quando, per esempio, lo strato di malta di posa si distacca dal nucleo (vedere diagramma). Il distacco puo` essere rilevato dal suono "vuoto", picchiettando sulla superficie del mosaico. Il distacco e` spesso associato a rigonfiamenti.

Vuoto: Spazio fra strati distaccatisi l'uno dall'altro.

Figure 2. Example of a visual glossary developed for the project for the conservation of mosaics.

necessary to continue recording it graphically. It will be easier for an experienced conservator to refine the list and identify the relevant elements to be recorded. However, as a general rule, it is important during the graphic data collection to stop after the first few days of work, evaluate and reconsider the list of elements to be recorded in graphic form.

Control of graphic records (Step 2.3)
During recording work, possibly at the end of each working day, it is good practice to review the graphic records to look for errors and missed areas. This operation is time consuming but very important, as it can be done only while in the field and will save future difficulties in trying to interpret data away from the field. A good way to maintain quality control and consistency is to do cross-control by having conservators check each other's work or by assigning the task of checking and organizing the daily documentation work to one team member.

Data organization (Step 3)
The data organization phase includes the following components:

- Editing of graphic information.
- Presentation of graphic information.
- Storage of graphic records.

Editing of graphic information(Step 3.1)
In the data organization phase, the graphic material collected in the field is reorganized and polished. The way the data is to be organized is guided by the objectives of the graphic documentation, as defined in the planning phase.

In the last three years, the GCI has opted to have all the graphic data in digital form since all the operations listed in this section – data organization – can be accomplished extremely rapidly with clear layouts. To achieve this, the information recorded in the field in hardcopy can be either copied or scanned and overlaid on the digital base map. "Copying" of data into digital form involves tracing manual records with a digital tool. This time-consuming and tedious operation is very prone to error and we try to avoid it whenever possible. The easier method is to scan the records and position the information on an appropriate layer in digital form. The transparency with the data needs to include registration marks (which allow for correct positioning on the base map), the scale of the record, and must be recorded with colours that can be scanned (yellow and green do not scan well). Although collecting data directly in digital form obviates the need for transfer to the digital domain, it still needs to be edited and organized.

The time and resources required for this component depend on how well the data collection phase was conducted. Ordinarily, a small team of conservators can more easily produce organized material, while a larger team's results require more effort to make them uniform.

Presentation of graphic information (Step 3.2)
Presentation is the stage at which the whole work is organized, studied, interpreted and presented to have an impact in the various aspects of the conservation project.

Graphic information can be presented in a wide variety of ways and the anticipated uses of the record guide the presentation choices. Data that has been recorded in different layers (either transparencies or digital layers) can be combined in a manner to aid interpretation, such as the location of plaster disruption and salt crystallization. The format of presentation of the graphic record depends on the audience and on the objectives of the presentation. Data in digital form offers the greatest flexibility, since layers can be turned on or off with a single command.

Within the life of a project, the function of graphic documentation may evolve; for example, initially it may serve for discussion within a multidisciplinary team regarding the distribution of a specific type of damage that may require further investigation. In this case, the graphic record may need to record not only the location of the particular phenomenon but also simultaneously provide related information, such as the location of drainage or heating systems that may be germane to the discussion. Another scenario might be that of obtaining consensus on a specific procedure among project partners; for example, graphic records may be used to describe the situation and to illustrate a schedule and budget for the completion of the work.

For whatever purpose, the graphic information needs to be presented over a base map, however schematic. If a photographic base map has been used, it may be preferable at this stage to substitute a line drawing that may allow for more legibility of the superimposed data. A line drawing can be made easily by tracing over the photograph. Moreover, when the graphic documentation is in digital form, the photographic base map can be switched on and off to allow a better understanding of the appearance of the painting and location of damage. The digital photograph can also be manipulated to have lighter tone so that it does not impede the interpretation of the graphic record.

Often it is very useful for the study of the object to have entire sections presented together. Summaries of specific elements can be prepared on these sections to illustrate a particular type of damage or a correlation between different elements. Typically, not all of the data collected in the field needs to be presented at one time. The selection of elements to be combined is based on the purposes of the presentation. In GCI projects, information tends to be grouped by type as much as possible; for example, previous interventions, structural condition, condition of the paint layer, etc. However, the main objective is the legibility and clarity of the information.

Similarly, the graphic symbols and colours used are not standardized but are selected to support legibility and to enhance the message that is represented by the graphic record. For example, indicating in red the most urgent and difficult problem.

Sometimes a situation may call for the record to be in black and white. For this, colours are substituted by hatching. Black-and-white documentation is often less efficient than colour in conveying a message but very easily reproduced. Ideally, try to have a coloured record that, if necessary, can also be read in black and white if photocopied.

The scale at which the information is printed will depend on the type of information represented. For example, a full wall ($57m^2$) of Cave 85 at the Mogao Grottoes can be printed in scale 1:20 to show the location of detachment areas, but to evaluate detailed condition, one has to produce the graphic record at a larger scale, such as 1:5.

Storage of graphic record (Step 3.3)

One of the objectives of documentation is to create a permanent record. To achieve this, graphic records must be archived for future use. It is important to produce a list of the components of the graphic documentation (original field hard copies, printouts from reports, CD-ROM with digital documentation files, etc.), indicating their physical location. This list must be included with the final project report.

Working in digital form facilitates the reporting, publication, storage and archiving of the data collected. However, long-term preservation of digital documents is certainly an issue due to the instability of the media and changes in technology; many file formats and hardware platforms eventually become obsolete. It is always important to create a final paper record for archival purposes; unfortunately, printouts are a poor substitute from the standpoint of functionality.

CONCLUSIONS

One of the principal challenges in the decision-making process for graphic documentation is the issue of what to record. This is crucial, since graphic documentation can easily become a disproportionately large task that exceeds the resources allocated (see Cather, 2000). In the planning phase, this crucial step of defining and listing of elements is conducted by the conservation team through a preliminary examination of the artwork. Through this examination, the possible types of information to be recorded are identified. Normally it is not possible to record all phenomena observed: not only would this be extremely time consuming but also potentially confusing for the interpretation of the final record. The difficulty is to determine both what is most significant and what is most appropriately recorded in graphic form. However, in the planning stage it is often very difficult to determine what is significant. Because of this, the tendency is to record as much as possible and revise the list as often as possible. Typically, a clearer understanding of the situation is reached after a few days spent looking at the object of conservation.

In discussing the use of graphic recording, one must also keep in mind that not all future uses can be anticipated, and therefore it is always better to include as much information as resources allow. However, one has to be aware of the time and money required for graphic documentation. Graphic documentation can easily become an enormous task and it is essential that the objectives and limits be stated clearly at the outset. Examples of graphic documentation that

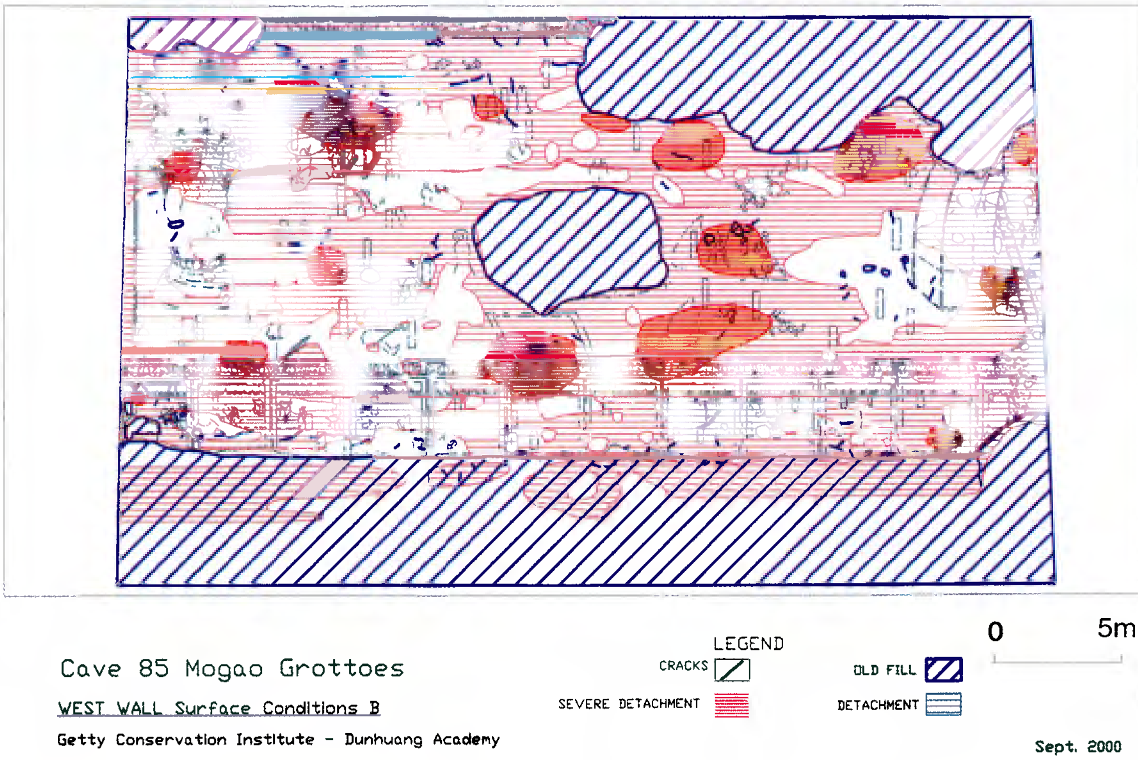


Figure 4. Presentation of the general location of detachment and priority detachment on the west wall of cave 85 at Mogao, China.

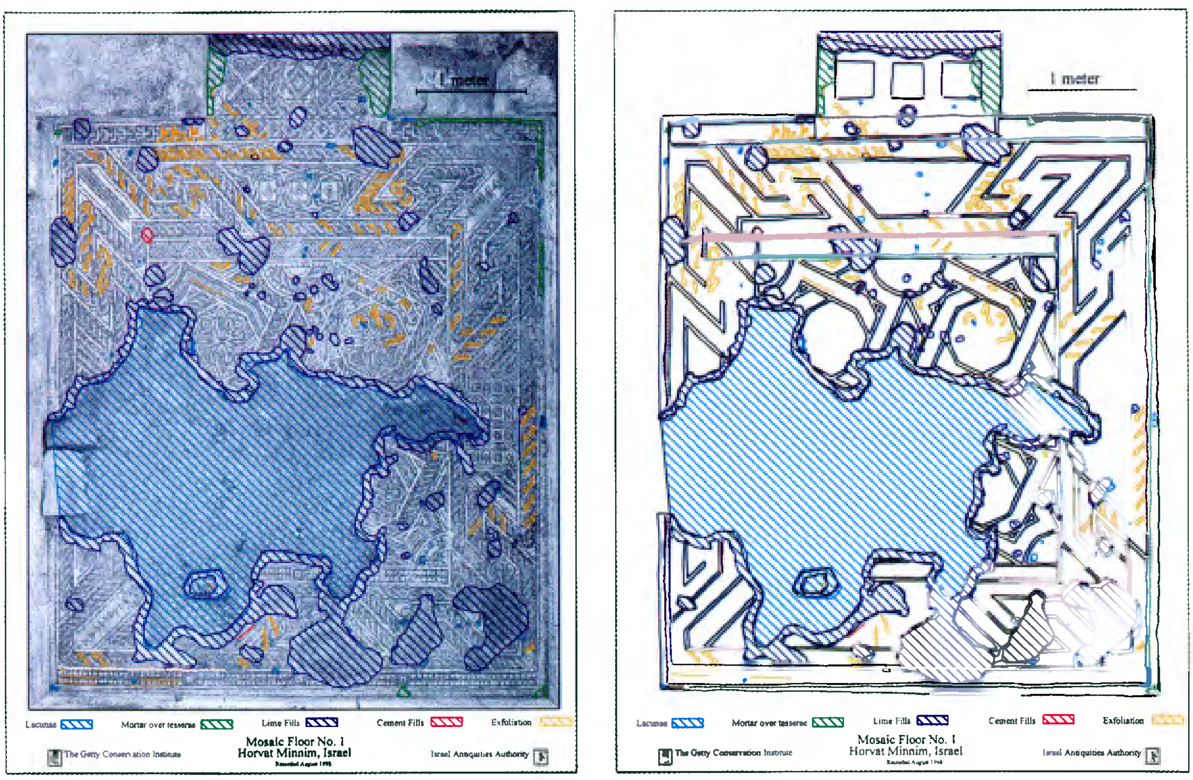


Figure 3. The same condition records of a Byzantine mosaic in Israel presented over a photographic base map and over a line drawing. While photographic base maps are very useful during recording, line drawings are less visually intrusive and allow for better reading in the presentation of the records.

are not integrated into the conservation work and become an object in themselves are sadly too frequent. Advances in technology have supported this trend by making it easier for conservation professionals to produce sleek graphic records that give a professional look to their work, even if they are not integrated in the development of the conservation plan and have little impact on the type and extent of the intervention.

Direct digital capture on site offers distinct advantages, being faster overall by eliminating the need to transfer data to digital form, with the consequent potential for transcription errors during transfer. In GCI experience, one of the major problems in carrying out digital documentation in the field is the complexity of the operation. Conservators can become bogged down by hardware and software issues and too much energy can be expended in making the system work. Therefore, it is important to keep in mind that the most important activity is the careful examination of the paintings and recording of the information in a systematic, objective and meaningful way. One way to take advantage of digital technology and to avoid technical problems in the field is to have a documentation specialist on site who is responsible for the management of the data and the smooth running of the system. This ensures that the conservation specialists can concentrate on their expertise – examination of the work of art – and can directly interact with the documentation specialist to obtain the correct graphic representation, making modifications to the system as required.

ACKNOWLEDGEMENTS

I would like to acknowledge my colleagues at the GCI, in particular Rand Eppich, Cynthia Godlewski, and Dr Gaetano Palumbo, and the GCI project partners who have been crucial to the continued refinement of these concepts.

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6

DIFFERENT DOCUMENTATION LEVELS ACCORDING TO THE TASKS OF A MURAL PAINTING CONSERVATION DEPARTMENT

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ABSTRACT

This paper describes the evolution and current state of mural painting conservation documentation in Mexico. The Mural Painting Conservation Department is responsible for a range of activities contributing to the conservation of not only mural paintings but also stucco reliefs, decorations, painted stone facades, and many architectural decorations.

Various services are provided to the whole country through the National Institute of Anthropology and History (INAH) representative offices, including:

1. Advice to restoration projects developed by INAH, private foundations or private restorers, at the beginning, during and until completion.
2. Assessment of the state of conservation, or performing condition recording tasks that have to be done in one or two days at most, usually as the basis for recommendation for a general intervention.

KEYWORDS: *wall painting; project proposal; conservation documentation; condition recording; levels of recording; Mexico.*

INTRODUCTION

Methodical documentation of wall paintings in Mexico is relatively recent, due in part to the late development of conservation in the country.

The first generation of professional conservators of movable heritage emerged only in the 1960s, and the first formal reports on conservation of wall paintings date from those years. The emerging conservators lacked a uniform format or structure that they could adopt, and so they all documented their work according to their own criteria. Some of these reports (unfortunately only a few) are sufficiently clear, and provide us with knowledge of the materials and techniques applied, as well as the precise location of these interventions; the others, in contrast, are totally vague, which makes it very difficult, thirty years later, to evaluate most of the first experiences with the conservation of wall paintings.

Figure 1. Bonampak, Mexico. Mayan wall painting.

From an analysis of these deficiencies, the late 1970s and early 1980s saw the appearance of the first proposals for standard formats and forms for systematically recording the data compiled in each intervention. Later on, the documentation generated during the interventions became more complex, as new generations of conservators arrived with greater professional development. The original proposals were outdated, as were the guidelines for the first reports. These later reports were documents in which not only conservators had a part, but also other supporting professional staff, such as chemists, historians, archaeologists or architects, in order to develop proposals for restoration interventions.

In this process, the National School of Restoration played a fundamental role in the discussion concerning what information should be included in a report, and where should the limit be drawn for research to solve specific conservation problems. This was subject to strong debate, especially in the areas of history and chemistry applied to conservation.

It was undoubtedly thanks to those academic discussions amongst the teachers leading the conservation seminars at the National School of Restoration – in this case the wall paintings department – that there was an attempt to define what were the aspects that had to be investigated and documented before, during and after a conservation treatment.

An unquestionable fact is that it is neither possible nor recommendable to isolate the study and treatment of a wall painting from the study of the building – even if it is a study that the conservator will lead only in general terms. Since in-depth research on this area is the field of the architect conservator, this factor complicates the documentation process enormously, in contrast with the documentation of other movable heritage, such as ceramics or sculpture.

During these experiences we were able to note that the formats that had been useful to document wall paintings located in pre-Columbian buildings were inadequate to document and research wall paintings from colonial and modern periods.

We had made such precise formats for a specific architectural context that they were useless for other types. We therefore had to rethink, in order to create a more flexible and general format, applicable to all sorts of buildings capable of housing wall paintings.

During this process, De Angelis D'Ossat's text on the *Causes of Deterioration* was of great help, as a guiding document that identified the parameters to study in order to define the causes of wall painting deterioration, even though this text was designed for the study of buildings (D'Ossat, 1972: 46).

From this document derived a scheme to follow for the implementation of wall painting conservation projects, which was later used by the Conservation Department of the National Coordination of Restoration. The Department is currently staffed by many professional conservators who were students and teachers in the late 1980s and early 1990s at the National School of Conservation.

DOCUMENTATION LEVELS GENERATED BY THE WALL PAINTING CONSERVATION DEPARTMENT AT THE NATIONAL COORDINATION OF RESTORATION

In 1995, new directorates and departments were created within the Cultural Heritage National Coordination of Restoration, which come under the National Institute of Anthropology and History (INAH). The aim of these new divisions was to address specific working areas, and hence the need for specialized working teams.

Before this, the conservators graduating from the National School of Conservation and who joined the Coordination worked on all kinds of heritage, including wall paintings.

The National Coordination of Restoration, in accordance with its directing function at a national level, generates various documents related to the conservation of both movable and immovable cultural heritage. The immovable heritage refers to wall paintings, altarpieces, etc. The difference between the various documents generated reflects the type of request being dealt with. INAH has offices in every State. Many of them have conservators working for the Institute, either as full-time employees or working under contract on the restoration of a specific object. Other offices, in contrast, have no conservator available.

The National Coordination has, therefore, to deal with several projects, with variable degrees of responsibility. It must accredit the professional capability of conservators, both from the Institute as well as external conservators, every time a conservation proposal arises.

In order to do this, every conservator who wishes to coordinate a project must submit their resumé, as well as a project proposal in which the following subjects must be addressed:

- Formal description of the object: location of the building, dimensions, author, possible painting technique used, stratigraphic description, and materials used.
- Historical background of the object, which must show, in detail, every transformation the wall painting has gone through. In a general way, the transformations of the building containing the subject and its environment must also be explained. From this study, one sometimes obtains information about the building's materials and construction techniques, or even of the wall paintings themselves, when, for example, one can find the original construction contracts.
- The geographic location of the building must show aspects such as the location of the building, its orientation, the climate, the kind of soil and local hydrology (including the water table) that might affect the building, and hence the wall paintings.
- Architectural analysis of the building and its stylistic or spatial modifications. This will be particularly relevant for wall paintings clearly affected by cracks, overhangs or any failure of the building. These problems will have to be solved before or during the conservation treatment of the wall paintings. In this case, the conservation proposal of an architect-conservator will have to be added to the wall paintings conservation proposal.
- From this study will also have to emerge an analysis to define whether the transformations have had a positive or a negative impact on the wall paintings.
- Detailed graphic and photographic recording of the wall painting and of the

building. Of special interest will be those elements that might determine the condition of the wall painting (roofing, adjacent walls, floors) in which the effects of deterioration might clearly appear.

- In order to achieve this condition record, we have provided every INAH office with a legend proposal in order to standardize the documentation at a national level.
- From all this information must derive a scheme of the possible causes of deterioration of the wall paintings according to the surveyed effects.
- The next step is a conservation proposal, based on analysis of the causes of deterioration, in which the techniques and materials to be used must de described in detail, and with a justification for their use.
- Proposal for further research. This research must focus on a precise definition of the deterioration that cannot be explained on the basis of the previous general analysis. The most common areas of research are definition of the construction technique, of the binding media used, of the paint layer, of salts, solubility, etc., or deeper studies to define humidity sources, architectural or soil changes, etc., which involve the participation of other specialists for development and execution of the project.
- References used.

When this information is received, a conservator from the Department is assigned to analyse it. If a relevant subject is felt to be missing after this analysis, the project conservator is asked to augment the information.

When the file is complete, the project is authorized, and the same conservator who checked the project must now monitor its implementation, for which they carry out periodic visits to the site. During these visits, the development of the project is monitored, and if something is incorrect, the visiting conservator must assist the on-site conservator to modify the work plan. In extreme cases of non-observance of authorized procedures, the project is stopped. The observations carried out on each visit are written up in a log, as well as in a report to be submitted by the Department's supervising conservator. At the end of the project, a copy of these reports is sent to the INAH office for archiving.

The conservator responsible must present, at the end of the work, a final report on the project, in which they record all the interventions carried out, in accordance with the first graphic and photographic recordings, together with a description of any possible modifications to the original plan, with their justification. Any new observations on the materials and techniques of the wall paintings that might have arisen from the analysis and studies undertaken must also be recorded.

When this report satisfies all the requirements, the conservator responsible is given a reception certificate for the report, confirming that the project has been successfully completed. This report is sent to the National Coordination of Restoration for archiving.

Within the states where INAH has conservators authorized to approve projects, they carry out the supervision of the project, and they inform the National Coordination of the development of the work in general terms.

In this case, the National Coordination of Restoration only carries out a 'supervision' of these reports, which are recorded in a database, and the regional INAH office keeps the complete record of the project in its archive.

On occasion, members of some communities or civil or religious institutions ask the National Coordination for an assessment on the conservation state of their wall paintings, as they do not have a conservator to turn to who could develop a conservation proposal.

The contracting of a conservator, as well as payment for a conservation project, is usually way beyond the economic resources of most of these groups interested in their cultural heritage. The National Coordination carries out the assessment and develops a report on the state of conservation of such wall paintings.

These reports aim to provide the soliciting group with general observations regarding the deterioration observed, as well as specific proposals focusing mainly on preventive conservation. A general cost estimate is also included, so that those interested can go to their local government or to the State government to request the necessary funds.

These groups are also advised on how to carry out some simple actions to minimize further damage to their wall paintings, such as the cleaning of roofs, drains and water channels, and removal of debris or garbage that might be damaging the walls or favouring the presence of humidity. They are also told how to constitute trusts, foundations or civil associations with the aim of soliciting economic or logistic support from national and international agencies.

The language used in such documents is much simpler, i.e. less technical. The main information is photographic, and the proposals are very general. Emphasis is placed on the budget necessary for completing each intervention.

DIFFICULTIES OBSERVED IN THE DOCUMENTATION PROCESS DURING THE TREATMENT OF WALL PAINTINGS

In summary, it is possible to say that an evaluation of the documentation generated in the past shows an important lack of analysis of the causes of deterioration. Most reports were limited to describing the object, as well as the materials employed in the restoration treatment, but without any precise assessment of chemical composition or on the application methods. There is no graphic documentation of the treatments, making the available information confusing and lacking in precision.

Figure 2. Bonampak, Mexico. Mayan wall painting.

One can find, for example, even for Mayan sites as important as *Palenque*, which were treated by archaeologists initially (during the 1950s and early 1960s), that "Ducco cement (1) and biocides were applied to the stuccoes at the *Palacio* [palace] in *Palenque.*" The building named *Palacio* on this archaeological site is of such dimensions that it is impossible to identify exactly where this material was applied. Nothing else is mentioned about the biocide, while Ducco cement is the commercial name of an organic polymer, whose chemical composition is unknown, but which was profusely used in the 1960s.

Later on, the documentation process became more extensive, and during the 1960s and 1970s the reports became more complex. Photography played a fundamental role in the recording of the treatments, although the information on the materials and their proportions remained cursory.

During the 1980s, reports included graphic documentation, sometimes superimposed over photographs to precisely locate the treatments and the materials applied during the restoration.

However, even in restoration projects as important as the ones on the Mayan wall paintings of *Bonampak*, carried out by at least three working teams of some ten conservators each (of which only four or five were full-time members), there was no minimum required format for the treatment report. Team members reported their activities in an individual way. Therefore, there is only a very fragmented view of these projects.

Currently, any properly trained conservator knows that thorough documentation of all the wall paintings of a building, and not only the area targeted for restoration, can help define the treatment criteria. Where is the limit for cleaning, replastering and chromatic integration? If we take any of these processes to an extreme in comparison with the other wall paintings within a building, we might be forcing future conservators to follow our approach, in order to avoid a contrast between one painting and another. Are there enough resources in my project to carry out treatments of this kind or not?

The same observation applies for evaluation of the integrity of the several paint layers of a building, especially if they cover a large area. Which layer or layers are better preserved? Will all areas have certain layers kept and others removed? What happens when this information is placed over the one considering the building's modifications with time, especially in the case of buildings that are several centuries old? The conclusions that might arise from this kind of analysis are determinant if we are to obtain a harmonic result in the decision making, such as choosing whether or not to eliminate a paint layer from a wall.

It is felt that experiences in Mexico show movement in a good direction. It is now opportune to adapt new technologies for the documentation of our cultural heritage, which will help us to make this process more efficient and agile.

At the same time, the inventories of cultural heritage in Mexico are still deficient. The labour is titanic if we consider the extent of known wall paintings in Mexico.

There are already some attempts regarding pre-Columbian wall paintings (de la Fuente *et al.*, 1997, 1998), but many of these attempts did not consider conservation condition recording, since they were done by art historians. In order to carry out this inventory, photographs were employed, but unfortunately most of them are of insufficient quality for future use as reference sources.

Architects have carried out the recording of colonial wall paintings, and these reports also lack condition assessments.

Regarding systematization of information concerning wall painting conservation, a project was initiated in 1999 to create a database with the various reports available in the archive of the National Coordination.

The use of laptop computers, video cameras and digital cameras was recently introduced for reports on damage caused to wall paintings by the recent earthquake.

We still have to systematize the monitoring of interventions carried out in the past, as well as their periodic evaluation. In the past, this task had fundamental significance, since it resulted in proposals to modify the materials that had been traditionally used in the conservation of wall paintings.

The improvement in documentation processes made it possible to evaluate recent interventions at the archaeological site of *Templo Mayor*, in Mexico city, a site where violent deteriorating agents are active. It was therefore a weathering laboratory for some of the materials that were considered a panacea in the past, such as polyvinyl acetates (Mowilith) and ethyl-methyl-methacrylates in emulsion (Primal AC 33). These were profusely employed in the past, but they did not pass the weathering test at this site, or at other sites in southeast Mexico.

All this led us to discard their use in certain environments, especially for unsheltered wall paintings; their use was limited to controlled conditions, such as those of a wall painting located within a museum, or within a closed area. Materials traditionally employed in the past were promoted – lime, calcium caseinate, gums and organic additives, such as those extracted from cacti or tree barks. Masons used such materials every day in the first half of this century, and yet later they were almost forgotten.

To summarize, adequate documentation allows us to:

- Better understand the causes and effects of deterioration, among which can be included previous restoration treatments.
- Make a coherent conservation proposal, in order to eliminate the causes of deterioration in the wall paintings, and therefore administer our resources in an adequate way, since they are usually very limited.
- Evaluate our treatment in the future, and therefore enhance the quality of our work.
- Avoid unnecessary or possibly harmful conservation treatments.

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7

DOCUMENTATION IN RESTORATION: POSSIBILITIES AND LIMITS OF VISUAL DOCUMENTATION FOR MURAL PAINTINGS

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ABSTRACT

The visual documentation of investigations and conservation measures on wall and ceiling paintings is not only a methodological and financial, but also increasingly a technological problem. Here, the question arises as to the long-term availability and archival quality of the documentation of conservation measures, which should be kept accessible for future generations.

Decisive factors for a functional documentation are – besides the co-ordination and methods of the procedure – the medium of the documentation as well as the means of communication. The electronic use of data will certainly serve in the future as an instrument of documentation in the field of restoration and conservation. But still, the systematic approach to an archiving documentation in the traditional way remains an aim worth striving for.

KEYWORDS: documentation (recording); documentation material; documentation media; photographic documentation; graphic documentation; visual documentation; qualitative and quantitative documentation criteria; mapping; photography; damage assessment (glossary); methodology; communication.

BACKGROUND

Preliminary documentation using black-and-white photographs (colour and digital photographs may also be useful) of the type and extent of damage is essential for establishing the condition of a work of art, and provides a basis for representing the damage quantitatively and qualitatively in visual form. Moreover, these photographs are helpful for mapping the findings and test results. Coordinated documentation of various damage phenomena, classifying the damage and the painting techniques into categories, can reveal the relationships, links and interactions among the different damage phenomena, and ultimately indicate the source of damage. Establishing such interrelationships is a prerequisite for drawing up a good conservation and restoration concept. Usually, the observations are drawn on an overlay placed on top of the photograph. The overlay thus takes on the role of information carrier between the work of art and its photographic image, and becomes a vehicle for interdisciplinary communication.

Drawings can also be employed for mapping, although they have to be first copied from photographs. They can concentrate on essentials and are, therefore, an efficient means of demonstrating the source and effect of damage. Both methods of documentation – drawings and photographs – serve the purpose of recording and evaluating observations, findings and experience according to phenomenological, morphological and structural criteria. Building up a glossary of damage phenomena is especially helpful in this connection. All communication requires a relevant means of expression: for graphic documentation, it is legends. In order to map observations and findings, i.e. data processing, visually perceived phenomena must be coded qualitatively and quantitatively, and translated into a symbol system, i.e. by creating an 'alphabet.' The simple act of putting the vital recorded data and information (e.g. analyses and technical evaluation) into visual form makes them valuable for drafting a concept. The quality of documentation does not depend solely on the accuracy of the observations, but rather on how they are communicated.

The visualization of construction problems as well as damage assessment in the field of mural painting conservation requires well-proven and systematic methods. From the point of view of documentation of the as-found condition, the conservator of mural paintings is usually confronted with two complementary tasks:

- preliminary examination of the mural painting, which is essential before starting treatment, as well as the mapping of these observations; and
- documentation of each single step in the conservation as the intervention progresses.

But only by means of a systematic compilation of firm investigation results can the data be scientifically evaluated and contribute to answer the questions of historical, technological, artistic or scientific research.

Systematic documentation or recording according to basic and scientific standards is, of course, not a recent invention, See, for example, early scientific publications on domestic or exotic fauna and flora or the detailed graphic documentation of study trips to foreign countries in the 18th and 19th centuries.

Carl Heideloff's study early in the 19th century on medieval ornament (*Ornamentik des Mittelalters*), for example, is a collection of illustrations of architectural ornaments. It shows all the features of documentation based on studies of the original, and could therefore serve as a basis for reconstructions and new buildings in the Gothic style. (Figure 1)

In this respect, one might also recall the first inventories of historic monuments, which can be considered as early documentation reports. In Bavaria, as early as 1835, the "General Inspection of Monuments" was entrusted with the task of "compiling illustrated records of all buildings, monuments, statues and carvings of artistic or historic merit."

In the second half of the 19th century, photography was to become – due to its rapid development – the most important instrument for recording and documentation in the field of monument conservation. The historian Jacob Burckhardt (1818-1897), for example, began to collect photographs at the end of the 19th century, but had no illusions regarding the comparatively short life of this new medium of reproduction: "Alles wird verbleichen, während die geringste lithographische Ansicht dauerte". ["All will fade, while even the simplest lithographic view lasts".] (quoted in Röttgen, 1996). It should also be remembered that the very early documentation work of archaeologists, particularly at the excavations at Herculaneum and Pompeii, played an outstanding role not only in respect to the history of mural painting, but also for the history of restoration and monument conservation (see Anon., 1889; Anon., 1981). (Figure 2)

Before the invention of mechanical or chemical reproduction methods, sketches, drawings and prints were the predominant method for recording observations. Especially noteworthy in this context with respect to the investigation of mural paintings is the documentary work of Joseph Archer Crowe (1825-1896) and Giovanni Battista Cavalcaselle (1819-1897) in their monumental *New History of Painting in Italy*. With sur-

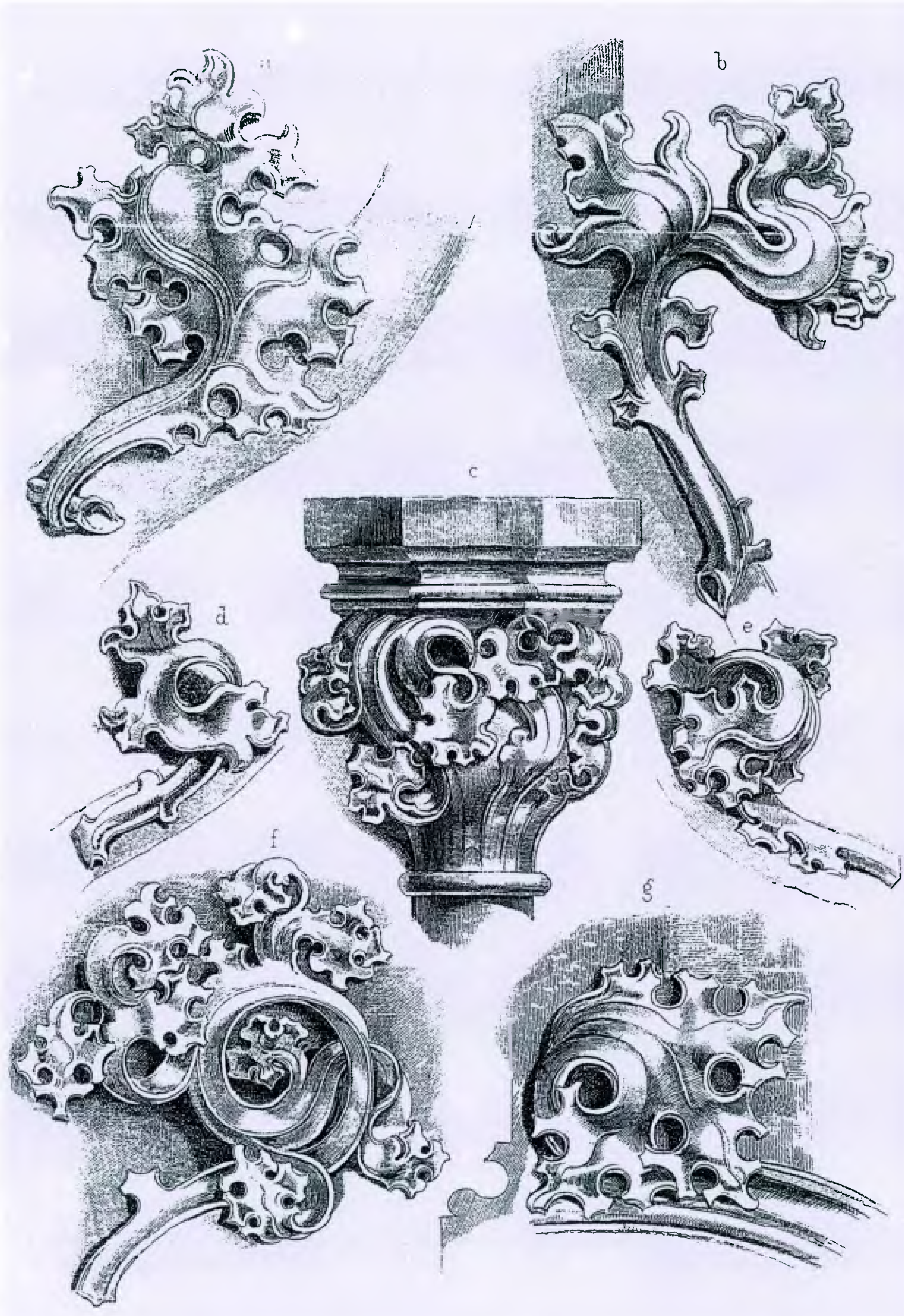


Figure 1. From Carl Heideloff, *Ornamentik des Mittelalters*, 200 copper plate illustrations with explanatory texts; new edition, Nuremberg, undated (ca. 1850), Vol. IV, Pl. 6.

Figure 2. François-Wilbrod Chabrol, Pompei, Tempio di Apollo ("di Venere"), sezione trasversale est-ovest, "stato attuale", Scala 1:50, e Restauro, Scala 1.33,3. "Feuille" II., from: *Pompei. Gli architetti francesci dell'ottocento*, Napoli-Pompei 1981, p. 141.

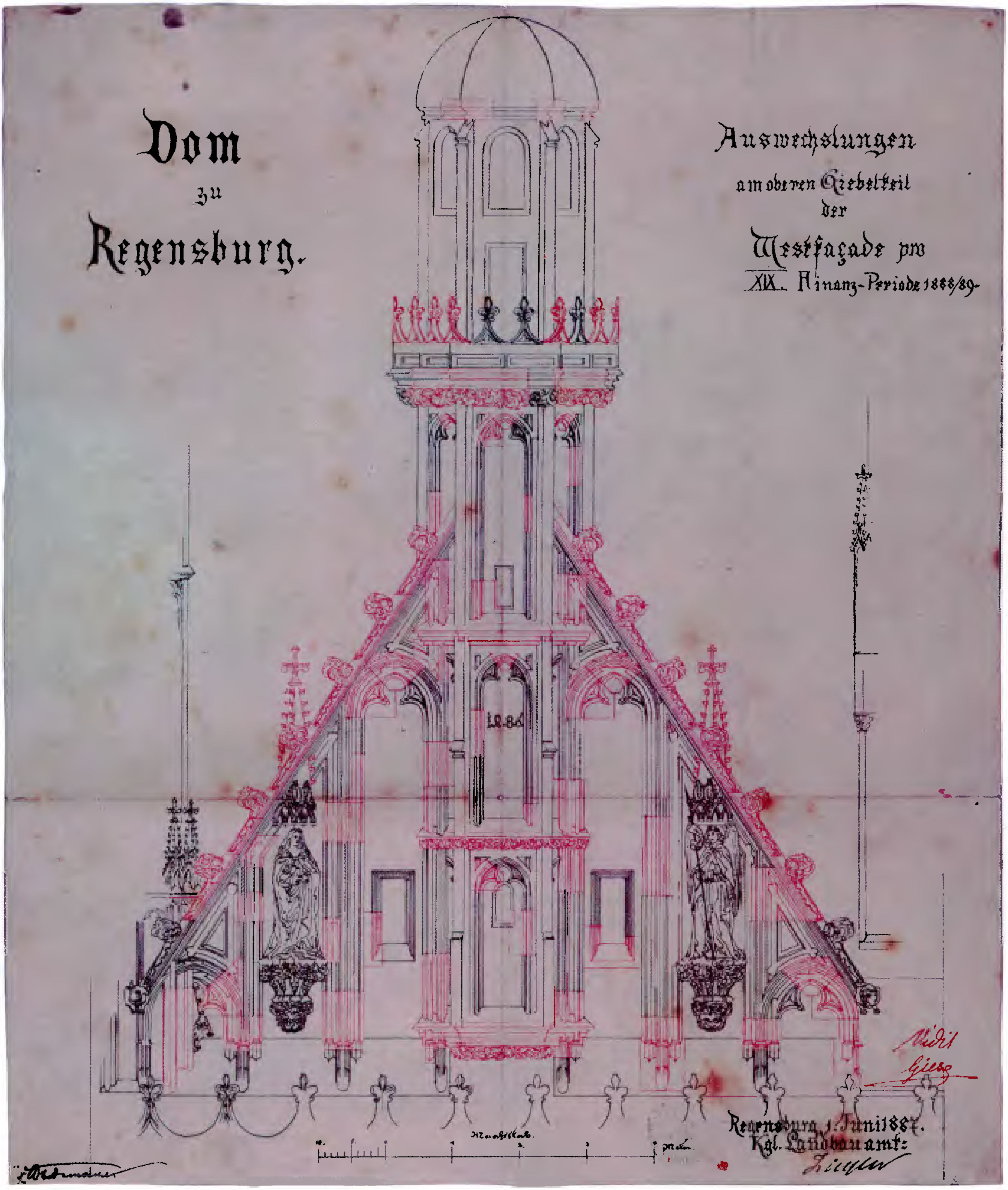


Figure 3. Restoration plan for the western pediment and the so-called "Eichelturm" from June 1st 1887. The parts to be exchanged are marked in red. Regensburg Cathedral workshop, from: *Der Dom zu Regensburg, Ausgrabung, Restaurierung, Forschung,* München 1989, p. 108.

veys and detailed sketches, including notes on colours, similarities and comparisons, they recorded a critical, art-historical survey of the problems of wall painting (Röttgen, 1996).

Sometimes these copies of important mural paintings – documents produced early in the 19th century – prove an irreplaceable source of information for the genesis of damage. Indeed, the collection of photographs of mediaeval wall and ceiling painting in Germany (*Bildsammlung mittelalterlicher Wand- und Deckenmalerei in Deutschland*, published by Richard Borrmann in 1910) has reached the status of respected documentation. Even the collection of baroque ceiling painting in Bavaria (*Corpus der barocken Deckenmalerei in Bayern*) produced in Munich, with its photographic documentation and art historical treatment, is regarded as documentation.

Until now, graphic documentation has remained the most common technique among archaeologists, architects and building researchers, and has also become an instrument for the visualization of specific problems in the conservation field. (Figure 3)

Overall documentation of a work of art is nowadays conceived as a comprehensive, multifaceted analysis, considering artistic and aesthetic as well as technical aspects. This kind of recording of the as-found condition, i.e. pre-intervention documentation, has grown to be a rather complex operation in the field of mural painting conservation. It has to take into consideration a wide range of parameters, including environmental exposure problems, depending on material and technique, as well as the influences of building physics, location and environmental conditions (e.g. ambient temperature) as fundamental factors in the preservation of mural paintings. For the preparation of often-requested consolidation measures, collecting, recording and combining comprehensive information is the most essential pre-condition for the preparation of a proper conservation plan.

METHODOLOGY

Right at the beginning of an investigation and documentation, one must define the preliminary research criteria, questions and contents, as well as the forms for presenting the facts observed. In order to make the documentation accessible to the user, the presentation of problems should not be speculative, but based on a methodical investigation of objective facts. This scientific ideal determines the standards and requirements for the investigation of works of art, which always has to combine the conservator's empirical experience and knowledge with scientific research: the result is a synthesis of individual findings.

As a consequence, all recording in conservation, damage assessment and documentation is based on this empirical synthesis. Such recording may be accompanied by climate measurements, thermography or, for instance, by the detection of irregularities in the plaster system of a mural painting using acoustic or ultrasonic techniques coupled with computer-aided evaluation. Most important are scientific analyses, which will mostly serve to identify causes of damage, but can also help to improve our knowledge of the technical aspects (the fabrication) and the material properties of the work of art in question. Therefore critical and fully elaborated documentation has a very important place in the visualization of the actual state of preservation.

During the last decades, the documentation of conservation measures and investigations has gradually developed into a seriously debated matter, and special publications have dealt with the topic for didactic purposes. Nevertheless, until now, there has been no overall consensus as to the structure and presentation of such documentation, even though mural paintings and the problem of damage assessment are basically the same everywhere. At least some sort of general standardization of archival parameters would be desirable, in particular of the archiving material for documentation or of the system of transmittal and forms of presentation.

Leaving aside the general obligation for investigation and documentation as formulated in the Charter of Venice, the questions and problems concerning presentation and setting up of documentation have mostly found rather individual solutions.

Again and again the question has been raised as to how documentation should be formed and structured without leaving information gaps that could lead to basic misinterpretation. Professional worries were aroused more recently by the gap that has apparently opened with the debate about relative merits of computer-aided documentation versus the traditional, long-established approach of documentation with paper, brush and pencil. The flood of computer and laser printouts and other types of copies can rise to an immeasurable volume during the process of documentation. Much too often, the archival qualities of the material produced are neglected in favour of immediate advantages such as faster and easier handling, quicker multiplication or more impressive presentations. The knowledge of materials suitable for archiving and the associated correct techniques are in danger of being forgotten.

The specific possibilities and qualities of visual documentation are most obvious in the case of architecture and related works of art (e.g. mural paintings) because of the technical nature of the large surfaces, which can only be understood in the context of their complex spatial and physical nature. For this reason, the investigation of mural paintings, recording of the as-found condition and their documentation pre-supposes the consideration of certain elements:

- qualitative and quantitative criteria for the evaluation of damage;
- representative or subordinate importance of each individual damage phenomenon; and
- exact, detailed or summary mapping.

For a detailed, first-hand mapping of observations, an enlarged high-quality photograph of the as-found condition or a comparable drawing support is sufficient; for motives of long-term archiving, the black-and-white print should be prepared on Baryte paper. Only the photographic support fulfils the Charter of Venice requirements for precise, appropriately matching correspondence between the observations and their mapping on durable, archival quality acetate. The overlay together with the photograph becomes a communicating bearer of information, and therefore the principal item in a graphic documentation. A precise and detailed damage-assessment, which is usually necessary for at least certain parts of any wall or ceiling painting, can only be successfully realized with the help of detailed photographs and enlargements of particular areas. The direct mapping onto an overly makes it possible to draw direct comparisons between different contents of the documentation and may contribute to decisive insights about the determining factors and connections of damage phenomena.

THE LINE DRAWING

The line drawing is of the highest importance as a bearer of information for a schematic representation, providing a linear and simplifying reproduction and transformation of the painting and its composition. In the praxis of conservation, only the disposition of a painting is usually copied from a photograph, and is somewhat comparable to an under-drawing. Drawings on paper have become one of the most important means of communication for investigation in the field of conservation. As a basis for such a line drawing, photographs made in the course of pre-investigations may be useful, as well as orthogonal measuring systems (photogrammetry) or digitized and corrected (orthorectified) photographic material. If available, exact, hand-drawn architectural survey or photogrammetric plan material may be used. (Figures 4 & 5)

For visualization of important interrelationships, combining the architectural survey with graphic recording on transparent film is helpful. The result is a map on a graphic support, with consequently a schematic 'survey character,' which can be understood as a static filling of the spread-out, two-dimensional outlines of certain types of damage.

From this type of record, basic information can be transformed and:

- used for evaluation, presentation and publication;
- can more easily be copied e.g. for the project partner; and
- can be archived and digitized without further expenditure.

The photograph and mapping layer in this system form a unity of communication tools and bearers of information. Simply by visualizing the data, the collection of information will provide:

- a critical analysis of the as-found condition;
- useful results for the development of a conservation concept; and
- secure findings and document them for the future.

Ageing and decay can now be checked at any time, and the efficiency of the conservation media and interventions becomes verifiable. In combination with the scientific, climatic and environmental investigations, such documentation will prepare the ground for a definition of damage processes on the one hand, and for their removal or repair on the other. It will also help in identifying ways to control damaging influences appropriate to the nature of the work of art, such as suit-

Figure 4. Wieskirche, district of Steingaden (Bavaria), fresco in the choir (J. B. Zimermann, 1749), drawing based on a photograph with graphical damage assessment and mapping of restoration interventions, from: *Die Wies. Geschichte und Restaurierung / History and Restoration*, Arbeitshefte des Bayerischen Landesamtes für Denkmalpflege, Bd. 55, München 1992.

Wieskirche
Zentralraum
Kartusche d (ZR II d)
Schadensbild
Ansicht, Grundriß

gezeichnet im Maßstab 1:10
(Reinhold Winkler)

Die Wies
Central space
Cartouche d (ZR II d)
Documentation of damages
View, plan

drawn to scale 1:10
(Reinhold Winkler)

Hohle und gelöste Putzflächen
Hohlstellen im Stuckbereich
Bruch ausladender Stuckteile
Haarriß
Klaffung des Risses, Angabe in mm
Versatz in Rißrichtung
ausgebesserte Bereiche
Putzrand in der Ansichtszeichnung

Separated plaster surfaces
Cavities in the area of the stucco
Breaking of projecting stucco elements
Hairline crack
Gaps between cracks, given in mm.
Shift in the direction of the crack
Repaired areas
Plaster edge in the plan drawing

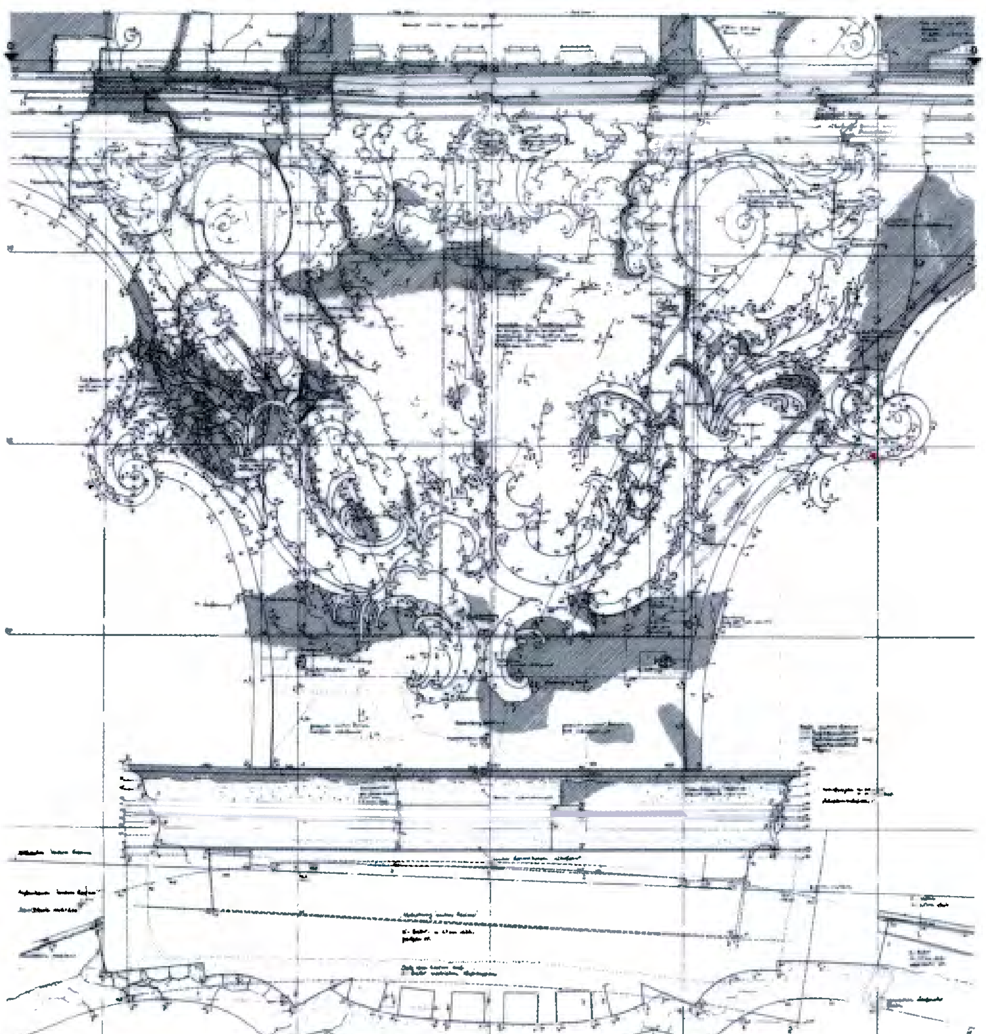


Figure 5. Wieskirche, district of Steingaden (Bavaria), stuccoed and painted cartouche (ZR II d) near a supporting, statically relevant position of the vault, manual architectural drawing (Handaufmaß), drawn in a scale of 1:10 (R. Winkler), with cracks and hollows inscribed, from: *Die Wies. Geschichte und Restaurierung / History and Restoration*, Arbeitshefte des Bayerischen Landesamtes für Denkmalpflege, Bd. 55, München 1992.

able means of protection against weathering, change of use of the building or monitoring of room climate.

Furthermore, significant elucidation of any mutual interdependence of damage processes is possible, as is produced by salt-influenced weathering, the formation of sulphate, or even a wrong proportion of fixatives, which may lead to disintegration of pigments.

If, in the course of the investigation and observation of the mural surface, individual damage areas are not only mapped and recorded individually but also overlapped and visually put into relation with each other, then the individual damage zones can be more adequately described and recorded photographically, and a detailed damage glossary built up. The filing system can be integrated into the investigation and allows a later evaluation of the causal criteria. (Figures 6 & 7)

THE DAMAGE GLOSSARY

A damage glossary is a systematic listing and visualized description of representative damage phenomena in a work of art or a building. The damage glossary represents the first step in approaching a problem. The damage glossary provides:

- qualitative orientation concerning the whole complex;
- delimitation and definition of the damage categories; and
- systematic visualization of concrete, ascertainable damage contexts by using various photographic methods.

The glossary comprises an image part and a textual part, together with supplementary schematic or explanatory drawings describing or outlining the condition. The observations made using the so-called 'coordinated' view and their systematic visual representation can lead to a suitable limitation and to a thematic focusing of the problems of preservation and conservation. This will furthermore lead to improved communication, clarification and specification of the contents, as well as visualization by means of representative image material. The damage glossary represents a mode of access to a systematic, logically structured registration and detection of ageing and damage processes. The essential advantages of its systematic use are:

- The collection of damage pictures, which serve – combined with the remaining information – as an interpretation of the damage phenomena and damage processes.
- The individual damage or damage group represents the entire damage group or damage category. Thus the documentation of the individual record becomes a kind of documentation element that will be considered representative for all similar records during the treatment. This helps to limit the documentation to really important records, which means that collections of large files with repetitions but little additional information will be unnecessary.
- The photographic documentation with one or several pictures should particularly reflect the typical features of the damage and its variations.
- A relevant number of glossaries would allow a more exact and differentiated definition of the pathology of the damage in plasters and murals through a feedback effect. This in turn would lead to more precise comparison and diagnosis. A catalogue of region-related or building-related damage symptomology could be produced, which could then be linked with other data, such as information on environmental factors, preservation methods and, above all, previously used preservation media and techniques.
- Using non-destructive initial examination, a general survey of the type of damage can be obtained.

At the same time, a list of records may be prepared, indicating in which cases more extensive examination must be carried out, such as the need for taking a sample or laboratory analysis to clarify the relevance of the damage.

MEDIATION FORMS OF CONSERVATION DOCUMENTATION

Text and symbols are the basis of our communication. The qualitative and quantitative information of maps have to be explained in words, which have to be related to images and combined with a graphic system of symbols and designating colours in order to make them comprehensible. Standard graphic symbols or colour characteristics form a

Schadensglossar

Deckenfresco von C.D. Asam/ Ovalsaal Schloß Alteglofsheim

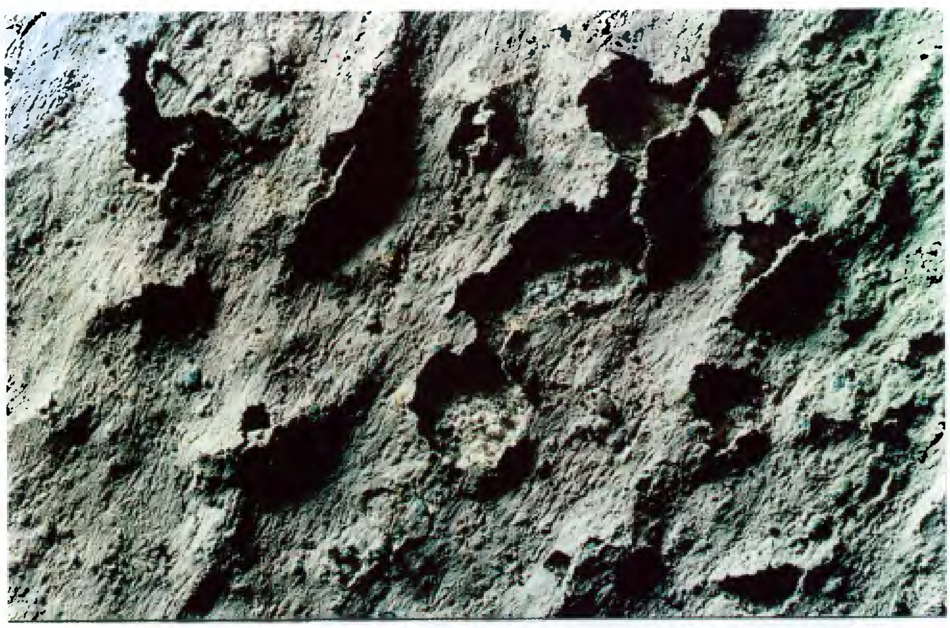
Malerei und Trägerputz		
P		Entlang den Haarrissen in den unteren Bereichen der Deckenmalerei sind einige Putzabplatzungen- zu vermerken.
P_H R_H		Hohle Putzpartien sind in den Verästelungen der Haarrisse in den westlichen Zwickeln des Gewölbes zu finden.
M_A	 	Vereinzelt trennen sind in dem nach außen exponierten Teil des Gewölbes kleinere oder größere Malschichtschollen von der Putzoberfläche.

Figure 6. Alteglofsheim, district of Regensburg, palace, oval room, ceiling fresco by C. D. Asam, 1730, damage glossary.

BEFUNDPROTOKOLL	FORTSETZUNG	Blatt
PLZ/Ort Str./Platz/Nr. Garmisch - Partenkirchen, St. Anton Deckenfresko von Joh. Ev. Holzer, 1736 Untersuchung: 1995, H. Zernickel		Befund-Nr.

Legende der graphischen Dokumentation, Beschreibung der vorgefundenen Phänomene.
Zustände / Schäden

04 Abplatzende Malschicht, Malschichtfehlstellen.



Bayerisches Landesamt für Denkmalpflege · Hofgraben 4 · 8000 München 1 · Telefon (089) 2114-1 · Telefax (089) 2114-300

Figure 7. Damage glossary, visual definition of damage phenomena: bursting or detached paint layer losses.

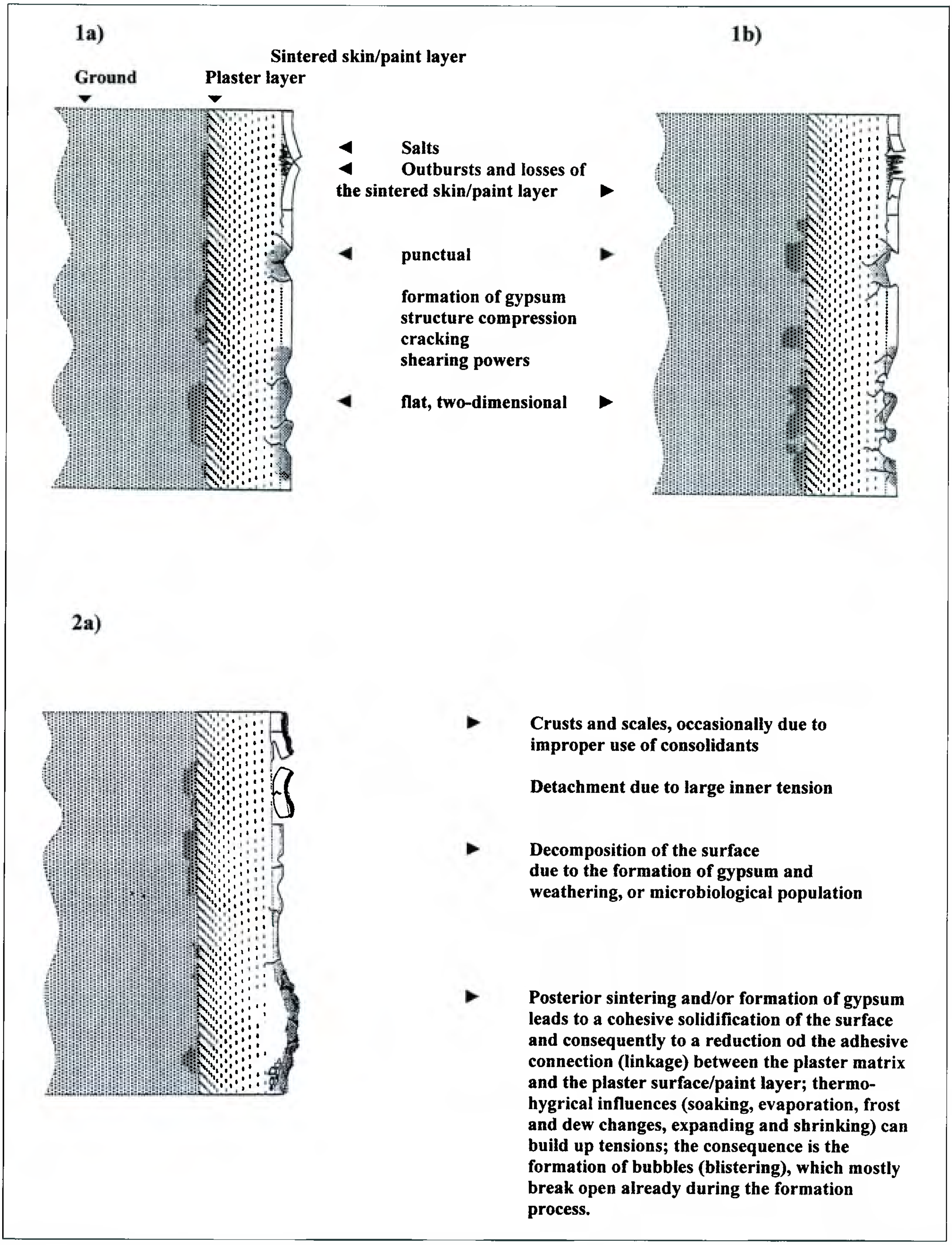


Figure 8. Typology of the damage genesis. Schematic sketches exemplifying the surface weathering of facade paintings (cfr: damage definition and damage glossary for wall paintings: Schadensdefinition und Schadensglossar in der Wandmalerei: Seminar thesis by Peter Ehrhardt, Hochschule für Bildende Kunst Dresden, Studiengang Restaurierung, 1996).

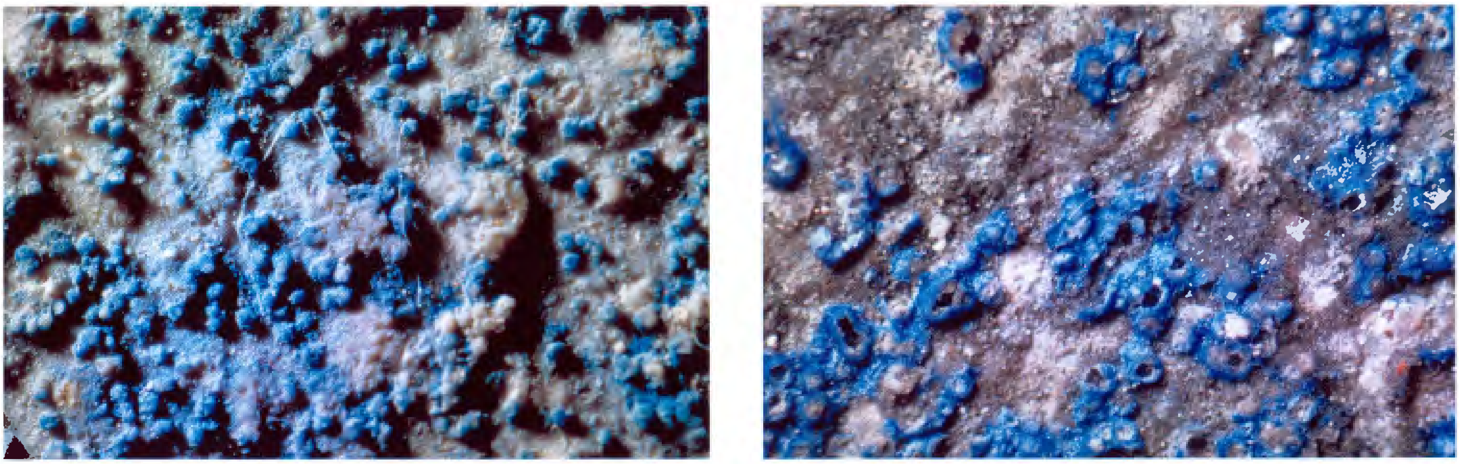


Figure 9 a/b. Blue colour layer (lapis lazuli) on grey veneda, dot-like and/or spherical changes in the paint layer (mostly through influence of humidity and the formation of gypsum).

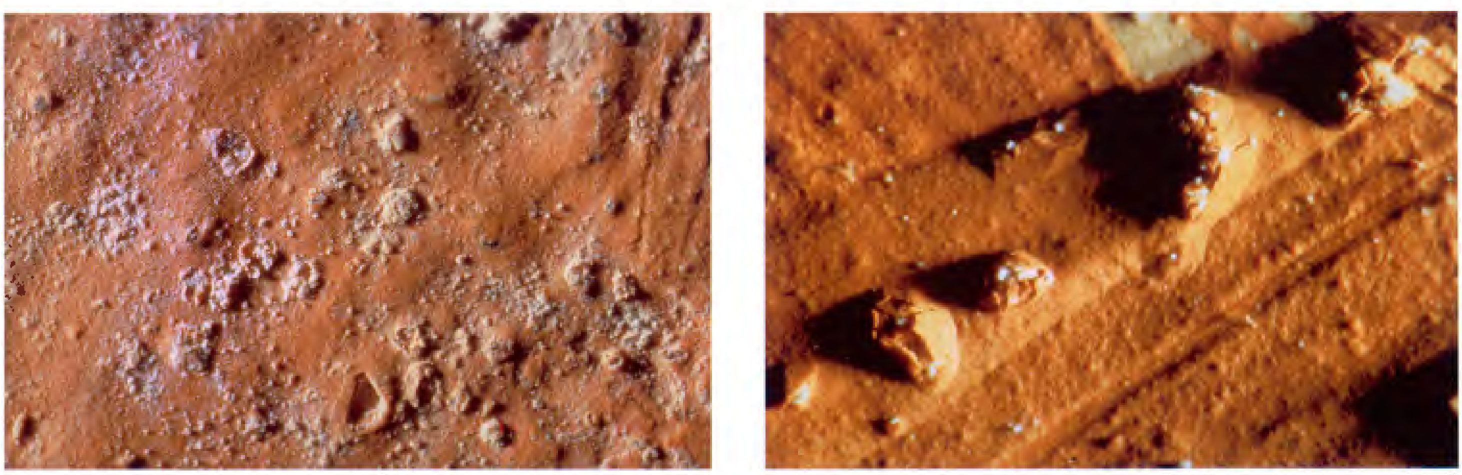


Figure 10 a/b. So-called pustules, dot-like crystallizations of salts (mostly through the formation of gypsum on the surface).

e: TECHNOLOGIE (mural paintings)
fr: TECHNOLOGIE (peintures murals)
it: TECNOLOGIA (pitture murale)
esp:
dt:TECHNOLOGIE (Wandmalerei)

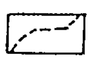
e:
fr:noir
it:nero
esp:negro
dt:schwarz

e:
it:Pontate etc.
dt:Verputzgrenze (Pontate etc.)
fr:limite del'enduit (Pontate ect.)
esp:

e:dark red
fr:rouge foncé
it:
esp:
dt:dunkelrot

e:
it:Giornate,
dt:"Tagewerke"
fr:Giornate (joints:2sur1)
esp:
2über lappt 1

e:yellow red
fr:rouge jaune
it:
esp:
dt:gelbrot



e:
fr:incisions dans l'enduit frais
it:
esp:
dt:Vorritzung

e:light brown
fr:brun clain
it:
esp:
dt:hellbraun

e:
it:
dt:Kart ongravur
fr:cal que au poinçon
esp:

e:blue green
fr:vert.bleu
it:
esp:
dt:blaugrün

e:
esp:
fr:poncif, it:spolveri
dt:Kartonpauspunkte, spolveri

Figure 11. Study on a multilingual definition and a code for representing damage phenomena on mural painting (Ivo Hammer), ICOM-CC Group "Peintures Murales et Mosaiques," Réunion du 25.11.1988.

Objektkennzahl: |_|_|_|-|_|_|_|_|-|_|_|_|-|_|_|	Bearbeitungsfläche:
Ort :	Kartierungsthema :
Landkreis :	Datum :
Objekt :	Bearbeiter :

Merkmal/Bezeichnung	Ziffer/Buchst.			Symbol	Signatur		Farbton	
Abb.1	1	A	I	△			RAL 1016 Stabilo 87/205	
	2	B	II	▲			RAL 1033 Stabilo 87/215	
	3	C	III	▽			RAL 2008 Stabilo 87/235	
	4	D	IV	▼			RAL 3002 Stabilo 87/315	
	5	E	V	□			RAL 3015 Stabilo 87/355	
	6	F	VI	◫			RAL 4006 Stabilo 87/340	
	7	G	VII	◊			RAL 5012 Stabilo 87/450	
	8	H	VIII	◈			RAL 5002 Stabilo 87/405	
	9	I	IX	○			RAL 6017 Stabilo 87/575	
	10	J	X	⊖			RAL 6005 Stabilo 87/520	
	11	K	XI	⦶			RAL 8001 Stabilo 87/685	
	12	L	XII	⊕			RAL 8014 Stabilo 87/635	
Risse	13	M	XIII	R				
Salzausblühung	14	O	XIV	■				
Reliefbildung	15	P	XV	▬				
Verfärbung	16	Q	XVI	⌒				

30 Blatt–Nr.

Figure 12. Example for a systematic documentation of the as-found condition of wall paintings; Blank Form 1: from: Bestandserfassung und Bestandsanalyse an Kulturdenkmälern, Materialien zur Fort- und Weiterbildung 1, Niedersächsisches Landesverwaltungsamt/Institut für Denkmalpflege Hannover, 1993. This system is based on the results of a research project on "Steinzerfall und Steinkonservierung" (Destruction and Conservation of stone) as well as "Wandmalereischäden"(Damage on wall paintings of the Bundesministerium für Forschung und Technologie (BMFT); first published under the title "Systematik und Legende für die darstellende Dokumentation in der Bestandsaufnahmne von Kulturdenkmälern," in a special edition of the periodical *Bautenschutz/Bausanierung*, 1992. Another blank form (Form 3) is available for data on object and location, with space left for drawings or photographs in the centre of the sheet as well as legends for the mapping contents. Both legend and 'mapping mask' can be used for manual descriptions as well as for further CAD reworking.

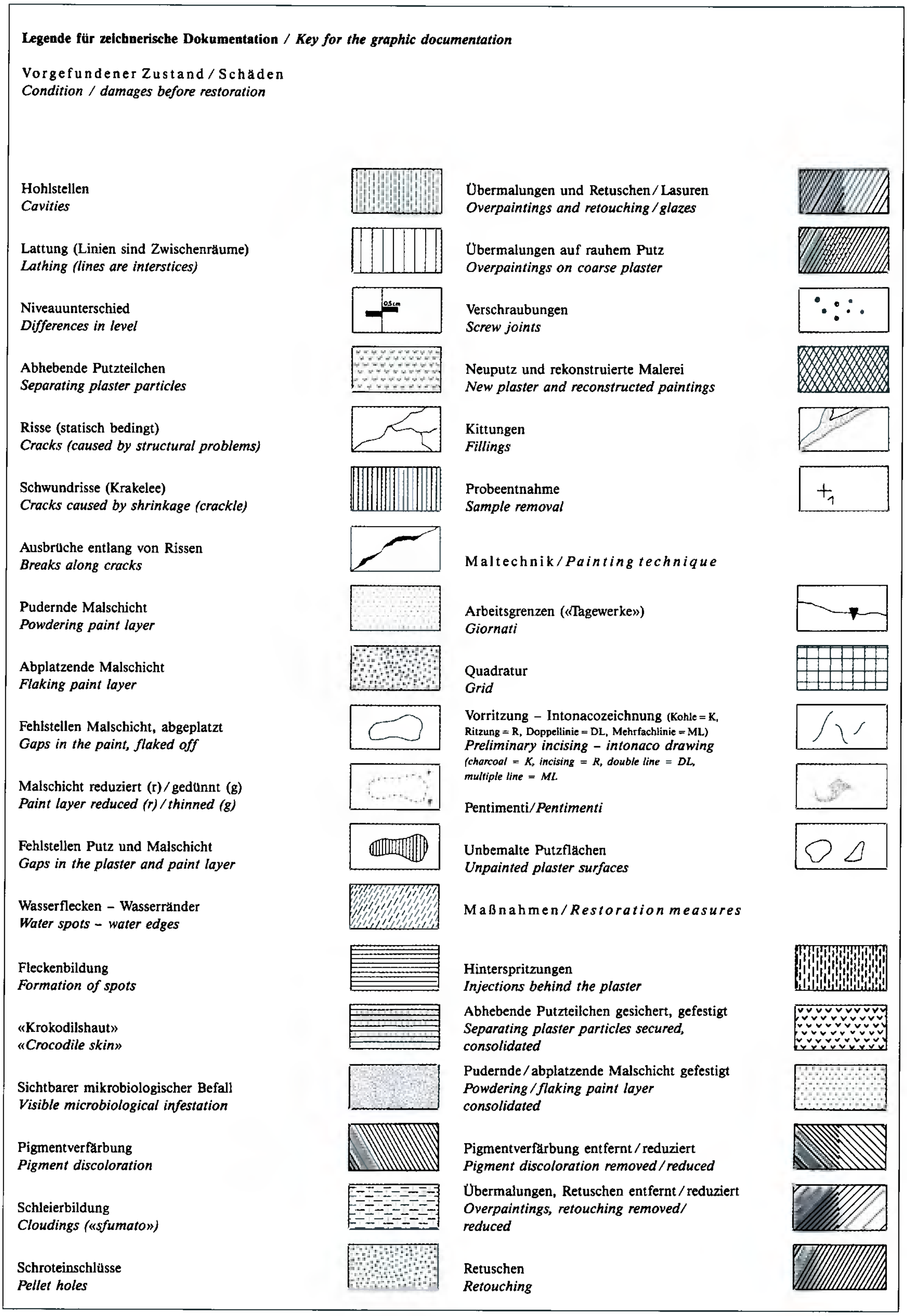


Figure 13. Legend for graphic documentation, from: *Die Wies. Geschichte und Restaurierung / History and Restoration*, Arbeitshefte des Bayerischen Landesamtes für Denkmalpflege, Bd. 55, München 1992, p. 229; cfr. Figure 4.

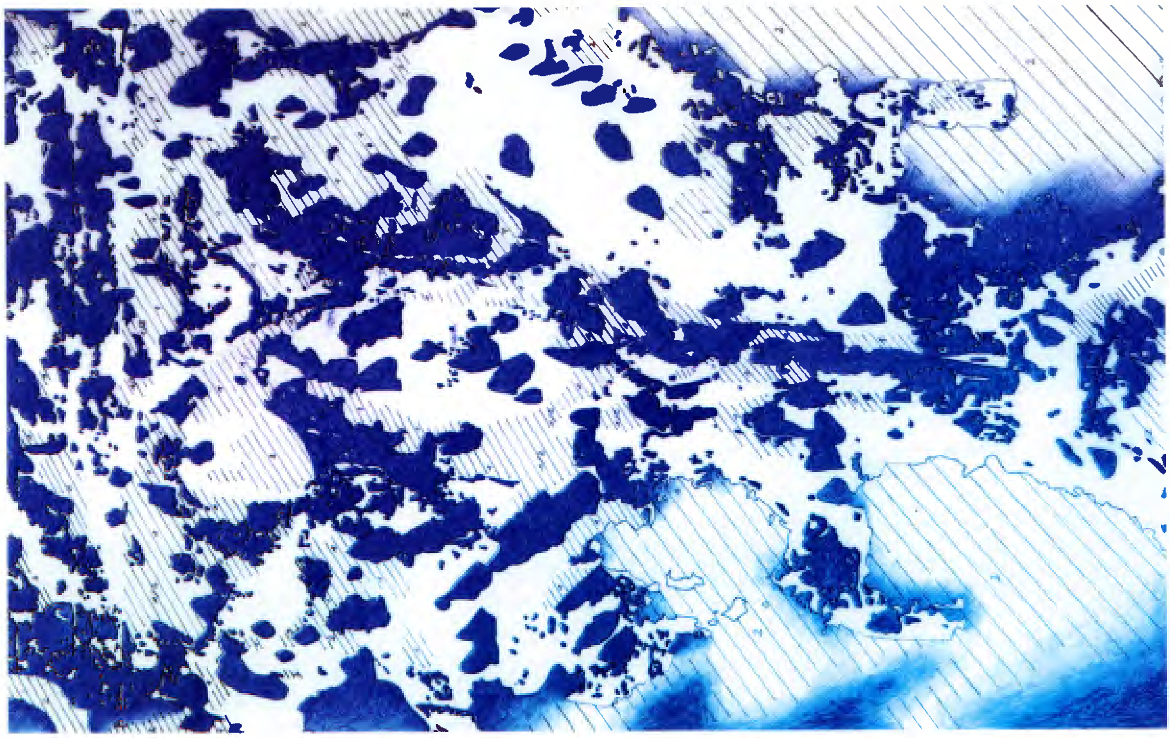


Figure 14. Augsburg, Fugger House, interior decoration of the so-called "hall of the muses" by F. Sustris/A. Ponzano 1570/71; detailed mapping of the heavily damaged original wall paintings on two plastic overlays over a detailed black-and-white photograph, coloured pencil and black ink (by C. Salzberger)

Figure 15. Munich, Ludwig-Maximilian University, lecture room no. 115, Ludwigstr. 28, R. V. Langer 1834, mapping of the salt efflorescence, foil on a black-and-white photograph, coloured pencil (detail).

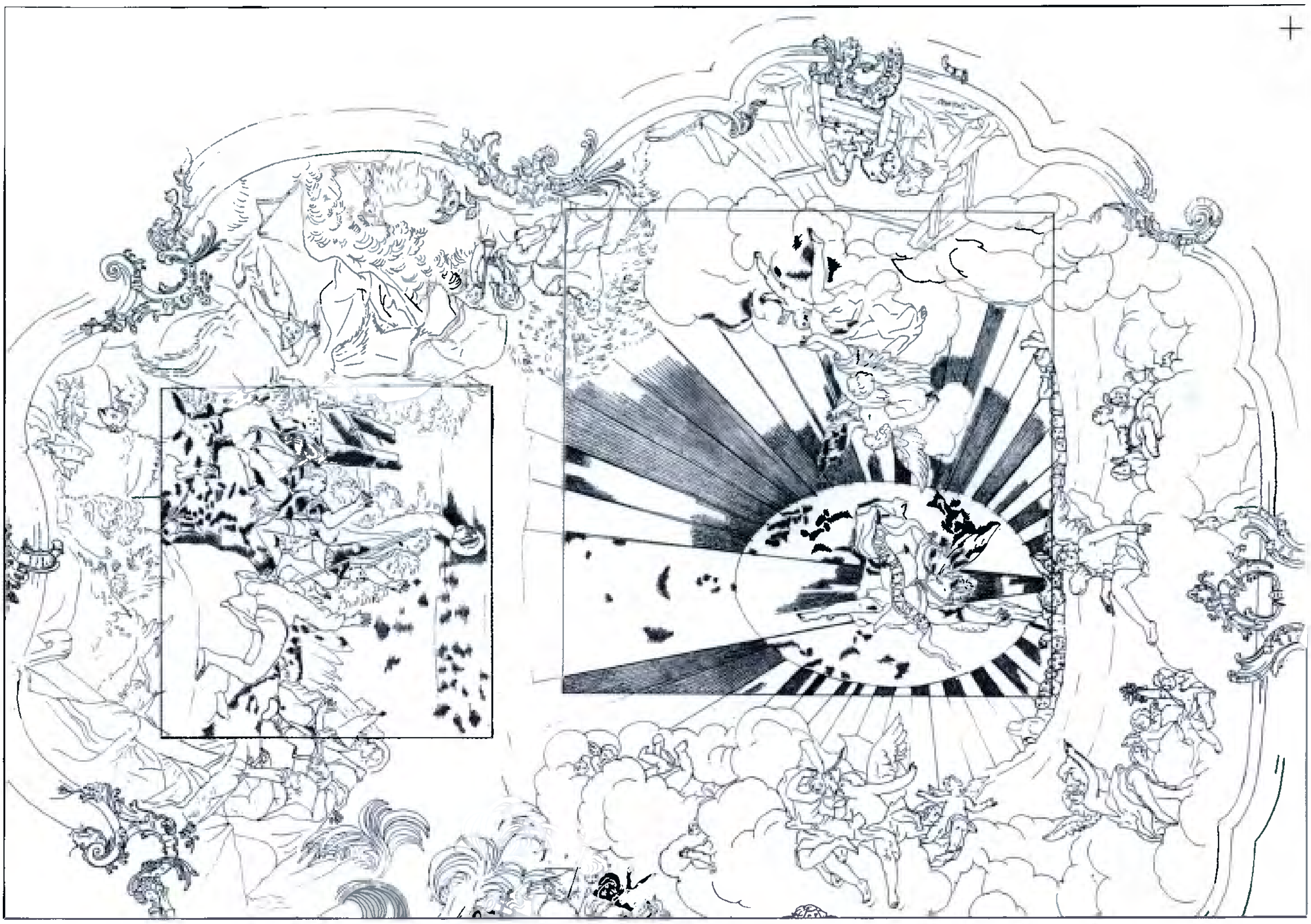


Figure 16. Pilgrimage church Vierzehnheiligen, district of Lichtenstein (Bavaria), J. I. Appiani 1764, choir fresco, graphic documentation drawing copied after a survey photograph (see Figure 4) with partial mapping with a lead pencil of repainting from the 'restoration' of 1959.

Figure 17b.
See Figure 17a.

Figure 17a. Alteglofsheim, palace, so-called "oval hall", C. D. Asam, 1730, graphic documentation drawn after a survey photograph (see Figures 1 and 16), mapping of paint-layer damage with a coloured pencil.

Figure 18. Landshut, former Holy Cross Church, G. Asam 1698; documentation of the damage on the paint layer and plaster surface: 1. Mapping of singular phenomena on location on black and white laser copies; 2. Transfer to a PC onto scanned photographs; 3. Coloured laser print.

legend. Unfortunately, in the field of conservation-restoration, an almost Babylonian confusion is still to be found. Virtually every conservator still uses an individual terminology, although an agreed and standardized alphabet and legend could promote improved standards of communication, as in the following examples. (Figures 8, 9 a/b, 10 a/b)

Every kind of graphic damage assessment can be read and evaluated quite easily with the help of a legend and symbols. Moreover, considering the worldwide network of communication systems and their qualities, which are functional and increasingly satisfy the needs and demands of conservators of historic monuments and sites, it is increasingly relevant how people present their observations in written form and how they visualize them. Certainly, some kind of choice must be left so as to match the subject matter, but a common basis for executing maps and documentation would certainly be a desirable achievement, not least in view of the future problems of archival longevity.

At this point the question arises as to which criteria? When should we prefer a coloured or a B&W representation? When would the use of colours be more appropriate, as a pre-condition for the introduction of symbols, special signs, figures or letters in seeking more generally readable documentation? The almost random use of graphic or linear symbols or of coloured legends makes any national or international comparison of recorded investigation results impossible.

In general practice, the desired multitude of possibilities could be achieved by only a small number of different symbols and colours, simply by repeated use of already-prepared legends under the most wide-ranging mapping contexts.

However, it remains important that the evaluation of the as-found condition of mural paintings will show – besides just the phenomenological features of the respective damage – also the relationship between cause and effect, such as the effect of thermo-hygrometric influences, or physical and chemical reactions and their resultant effects. (Figures 11, 12, 13, 14, 15, 16, 17, 18)

CONCLUSION

In the absence of any skeleton agreement or basic regulations, the standardization of conventions for types of recording and documentation is difficult, and in the long run can probably only be achieved by introducing certain rules into the curricula for conservator-restorers. An overall and generally accepted methodology and form could be more effectively achieved by the use of special software for PCs, because in this field all accepted structures usually can reach at least a certain accepted standard. Nevertheless, the archival lifetime of digitized and recorded documents is still unknown. The question of the possibilities for archiving the material for long-term access should be discussed.

No matter on which level documentation has been made and what kind of material has been used, the question will always be whether or not the product is of archival quality. The variety of drawing papers, and particularly of the various commonly-used writing and copying papers (not to mention slide frames, overlays and colour pens) at present makes any attempt at regulation nearly impossible. Here, precise recommendations for everyday use are needed for the field of preservation and conservation of monuments. A first attempt at discussion of the possibilities and limits of documentation, recording and archiving of documentation materials in this field was in 1989 (Anon., 1994).

In the course of a methodical process and first-hand contact with the work of art, the mural paintings conservator responsible for recording and documentation of the as-found condition will have to set up the principal items of the pre-investigation and the framework for the conservation project, consisting of a qualitative and quantitative damage analysis as well as the mapping of all interventions. In consideration of the advantages and disadvantages of recent practices in computer documentation techniques in the conservation of mural paintings, it seems to make sense to seek a long-term archiving system in order to preserve for future monitoring and research the first-hand investigation material on wall and ceiling decorations. There can be no doubt that priorities have to be set in the application of such measures, which will always remain related to the general appreciation and esteem of the work of art concerned.

Archival quality of the documentation material means the use of durable materials: paper, pencil, colour pens, drawing film and China ink.

What is the point of using time-intensive and expensive documentation products, if not to guarantee proper storage and preservation of investigation results for future generations? For daily needs, for routine maintenance and monitoring, for presentations of different kinds and publications, of course, all forms of computer-aided software based on current communication and reproduction systems may be useful.

ACKNOWLEDGEMENT
For translation into English, the help of Dr Susan Tipton, BLfD Munich, is gratefully acknowledged.

NOTES

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8

DOCUMENTATION IN THE FOURTH DIMENSION

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ABSTRACT

Developments in digital imaging and automated data collection allow a shift of emphasis away from treatment-orientated graphic condition recording toward documentation as an analytical and investigative tool. This paper discusses the importance of capturing salient information, referenced in both space and time. Registering wall paintings in three-dimensional (3-D) space recognizes the wall painting as an integral part of the building envelope. This in turn facilitates monitoring through repeat recording over time. Documentation in four dimensions (4-D) allows assessment of the rate and pattern of change. Moreover, combining time-referenced imaging with other data sources aids identification of deterioration activators, thus moving us towards passive control, rather than reactive treatment. The number and required accuracy of measurements is flexible, and should be related to the specific conservation problems. Many types of diagnostic imaging techniques are now available within conservation, which are often best presented dynamically using multimedia.
KEYWORDS: wall painting; conservation; documentation; monitoring; imaging; digital; recording; environmental; time-lapse; infra-red thermography.

BACKGROUND

The advancement of computer technology and its widespread adoption over the past 15 years has lifted the lid on the potential for documentation in conservation (Cappellini *et al.*, 1984; Eppich and Piqué, 1999). However, generally speaking, the result of this technical progress has been to focus limited funds on 'improving' the final presentation of reports, and providing 'greater' levels of accuracy – whether real or perceived – through digitization of the graphic documentation process. Where final reports once contained hand-drawn graphics, with annotated photographs or acetate overlays, these have been largely replaced by digital copy. Yet it is not entirely clear what this means in terms of cost and quality, archiving, or usefulness of the documentation. Importantly, this lack of definition means that documentation, as with other conservation activities, does not have a payment structure based on 'standards.' Consequently the cost and type of documentation produced by conservators varies enormously. We need to define the various elements of the documentation process and evaluate these against performance criteria and cost.

The action of the environment on a wall painting involves many, often interrelated processes that combine to cause deterioration. Yet we know remarkably little about the dynamics of these decay mechanisms. Documentation can be the tool by which we improve our understanding of the complex interrelation of the wall painting with its support and environment. This demands investigation and requires measurements and sometimes data collection. It is only through increasing our knowledge in this manner that we can hope to successfully influence the rate of deterioration in the long term.

DOCUMENTATION AS AN ANALYTICAL TOOL

Conservation documentation can now be successfully integrated with diverse types of data, in a way that was often not practicable, or possible, without the use of computer technology. In particular, developments in digital imaging and automated data collection allow a shift of emphasis away from treatment-orientated graphic condition recording, towards documentation as an analytical and investigative tool. This paper discusses the importance of capturing salient information, referenced in both space and time, to correlate (and thereby reveal relationships between) the activators of perceived deterioration, and the rate at which it is taking place. While it is recognized that this may not be applicable in all situations, nor affordable to many private conservators, the intention is to demonstrate what can be gained through the use of dynamic documentation. Moreover, as equipment costs fall and systems improve, it is hoped that such scientific visualization will be introduced into mainstream conservation use. The content of this paper comes from ongoing research and development work funded by English Heritage and the Getty Conservation Institute, and undertaken by the author at the Courtauld Institute of Art.

It has long been argued that the emphasis on treatment in wall paintings conservation needs to be redirected towards investigation and understanding (Cather, 1993). The importance of this shift in balance between investigation and intervention still needs wider recognition and acceptance within the profession. By redefining its uses, documentation can play a significant role in achieving this. Most typically, documentation is used to answer the question: 'What is present?' However, the question: 'What is happening to what is present?' is a more challenging, and far more fruitful, avenue of inquiry. One needs to consider the causes of deterioration, and the mechanisms and rate at which such processes take place. Such an approach – as exemplified by the work of Arnold and Zehnder (1991) – is a process of information gathering and analysis that is not only useful for informing conservation decisions and planning remedial interventions, but can also facilitate the assessment of complex problems.

Documentation, therefore, needs to be more scientifically rigorous if it is to be extended from simply providing a record of the types and distribution of deterioration phenomena, to actually aiding the investigation of processes. This would lift documentation and monitoring onto an entirely new level, as an analytical tool for diagnosing the fundamental causes and rate of deterioration. In response to an increasing awareness of the complexity of deterioration processes, it is now reasonably commonplace for parameters relating to their mechanisms to be recorded. This is a step in the right direction if assessments are to be based on measurements of what is occurring, rather than mere assumptions. However, for this to be successful, the information gathered has to be correlated and presented.

4-D DOCUMENTATION: REFERENCING SPACE AND TIME

The greatest visual tool in conservation documentation has been the camera, and photography is still the most widely used means of recording. The future of 'objective' documentation lies in digital imaging, and its manipulation and analysis. While affordable digital cameras cannot yet compete with the resolution of film, the current rate of development is such that this will not remain an impediment for long. Moreover, digital cameras offer significant advantages over their analogue counterparts. In particular they are sensitive to extremely low light levels, and the image can be viewed and adjusted, prior to capture. Following *in situ* capture, an increasingly important aspect of digital documentation is to annotate and enhance images (Saunders and Cupitt, 1995).

Since it should be possible for image enhancement processes to be standardized and referenced, direct-capture and image manipulation methods potentially allow conservators to spend more time looking and interpreting. In other words, their role shifts from that of writer to one of editor. Thus, automated imaging techniques will have the advantage of removing the subjectivity of conservators. However, often we cannot record or 'capture' much of the information we need – or in some cases even know what information we need. Among the technical difficulties associated with *in situ* data collection listed by Wong (1997) are the following:

- representing varying levels of intensity within each deterioration phenomenon;
- recording superimposed (overlapping) phenomena; and
- recording subsurface phenomena.

The advancement of imaging (particularly laser and multispectral technology) is improving our ability to detect, isolate, and record these phenomena. However, while our inability to record phenomena effectively will doubtless remain a major difficulty, conservation imaging should continue to benefit from technology transfer from space, military and medical research.

Due to their intimate relationship with the host structure, factors that affect the building envelope (such as transfer of moisture) also affect wall paintings. Deterioration phenomena are therefore often spatially differentiated, reflecting their nature and provenance. Consequently, phenomenological recording needs to be undertaken on a three-dimensional basis, to reveal patterns of distribution, and aid identification of the sources of deterioration (Cather, 1993). This can be done in a very simple manner through the production of 2-D perspective views; or with the use of more sophisticated tools such as CAD mapping, to construct a 3-D spatially referenced map of the site.

Although time consuming and costly to produce, the advantages of 3-D data plots are such that the building plan, interior and exterior elevations are fully integrated and located within a single framework. Baseline data of this sort should, however, not be restricted to condition surveys. There are significant benefits to be gained from incorporating other important diagnostic information (e.g. environmental data) together in one package. The digital site model may also contain information on other structures, and trees, etc., that surround the host building. Also, the wire-frame produced can be rendered with mosaic images, giving the viewer the ability to change position and zoom in and out. All this gives far greater control and opportunity for interrogating data in terms of its relational aspects in space. Using such a tool, it is possible to identify complex relationships (for example the movement of sunlight and associated moisture transfer pathways), which would otherwise not be immediately apparent.

4-D MONITORING

Monitoring of surface change can be undertaken in two general ways, differing from one another in terms of the recording interval. Long-interval monitoring can measure surface change by recording referenced images at different times and comparing them to ascertain or quantify change. Alternatively, continuous or short-interval monitoring, by reducing the recording interval and zooming in on detail, can be used to record the dynamics (rate and stages) of surface change. For example, such a technique has been used to record the growth of salt efflorescence on wall paintings (Trapp, 1994; Autenrieth and Turek, 1994).

Time-based presentation of documentation, including digital movies and animation, is an area with great potential in conservation. Clearly, the human visual system is very adept at interpreting data, but the shortfalls in human capabilities – such as concentration, accurate calculation and time measurement – can be assisted by referenced data. Therefore, the synchronization of image and data is highly desirable since this synergistic combination can provide unique information. Scientific visualization of dynamic processes can be achieved using time-referenced imaging, with simultaneous (real-time or rapid) graphical display of text and numerical data. Previous research has been undertaken to monitor dynamic processes by plotting both images and data against time (Heritage, 1995). This resulted in the development of an automated time-lapse system which combines video microscopy imaging, with automated image and data capture, manipulation, and superimposition of computer graphics (Heritage, 1999a). Images annotated with relevant parameters allow more objective assessments of the 'rate and nature of change'. This type of comparative information allows analysis that can reveal complex patterns and interrelated event information (including hysteresis) that are not readily discernible – or even apparent – if images and data are viewed separately. Moreover, coupling time-lapse imaging with data can facilitate the accurate measurement of change (position, size, shape, etc.) over time.

CASE STUDY: IMAGE AND DATA INTEGRATION

A combination of time-lapse and diagnostic imaging has been used to assess the effects of heating on wall paintings. Infra-red Thermography (IRT) was used at Hardham Church in 1996 to assess the influence of the electric heaters on the painted surface by imaging the surface temperature during heating (Figures 1 and 2). The deterioration of the 12th-century wall paintings at Hardham has been the subject of extensive investigations by the Courtauld Institute and English Heritage. The paintings are principally affected by salts and organic coatings – the most problematic of which is a modern synthetic, applied during the 1960s. This material is hygroscopic and undergoes rapid and extreme dimensional alteration in response to fluctuations in relative humidity (RH), resulting in severe flaking and loss of the painted surface. *In situ* IRT recordings of the wall surface temperature during a period of heating were combined with simultaneous environmental monitoring. The data shows that the effects are rapid and dramatic: after 1 hour the surface temperature (ST) had increased by 1.7°C and the ambient temperature (AT) 3.5°C, while the RH had decreased 14%. At 2.5 hours, the rise in AT was +4.4°C and the RH had fallen 18%. The ST continued to rise at a steep rate (to an eventual +3.6°C). Interestingly, the rates of change during cooling were even more rapid: after 90 minutes all three parameters had almost returned to their initial values.

When comparing this data to time-lapse recordings (QuickTime movies) of the coating in response to fluctuations in RH (undertaken at the Getty Conservation Institute) the cause of the excessive flaking surrounding the heaters becomes clear and, importantly, demonstrable. In this particular instance, the moderate increase in temperature is not directly responsible for the damage, but rather the associated drop in RH that is produced (Heritage, 1999b).

DISCUSSION

It is a platitude to say that conservation is and must be an interdisciplinary field. However, we are all well aware of the difficulties of defining the role and responsibilities of those individuals involved, and of maintaining good communication among them. Particularly in wall paintings conservation, the introduction of increasingly sophisticated technology has meant that many other specialists have become involved. The net of responsibility and expertise is now cast wide to embrace diverse professionals such as architects, structural surveyors, and engineers, in addition to the traditional triumvirate of art historian, conservator and scientist. In the specific area of documentation, this list must also be expanded to include experts proficient in the practice of metric survey work, photogrammetry, CAD and so on. Monitoring – for example of environmental parameters – tends to be undertaken by specialists, whereas conservators typically undertake the condition recording. Indeed, these exercises are often seen as so completely independent of one another, that they are commonly phased and financed separately. This situation is unfortunate, as it overlooks the great potential value of combining such investigations.

Those with direct, or even indirect, experience of computer-based documentation will be acutely aware of how time consuming and expensive an exercise this has become. It is therefore imperative upon us all to ensure that the maximum benefit is extracted from our endeavours. To this end, it is necessary to question both the ways in which documentation is undertaken, and what its intended uses are. As we move away from treatment-orientated conservation towards informed intervention through investigation and assessment, it will become increasingly important to have documentation systems that can store, manipulate and present diverse information. This will improve not only our own understanding of conservation, but also that of other professionals and the general public through education and dissemination. Some examples for this would be: the documentation of treatments using time-referenced techniques (time-lapse through to high speed imaging); using animation techniques to show processes (e.g. moisture paths in a building envelope); or by incorporating recent and historic images in sequences to show change over time (e.g. photographs, condition survey documenta-

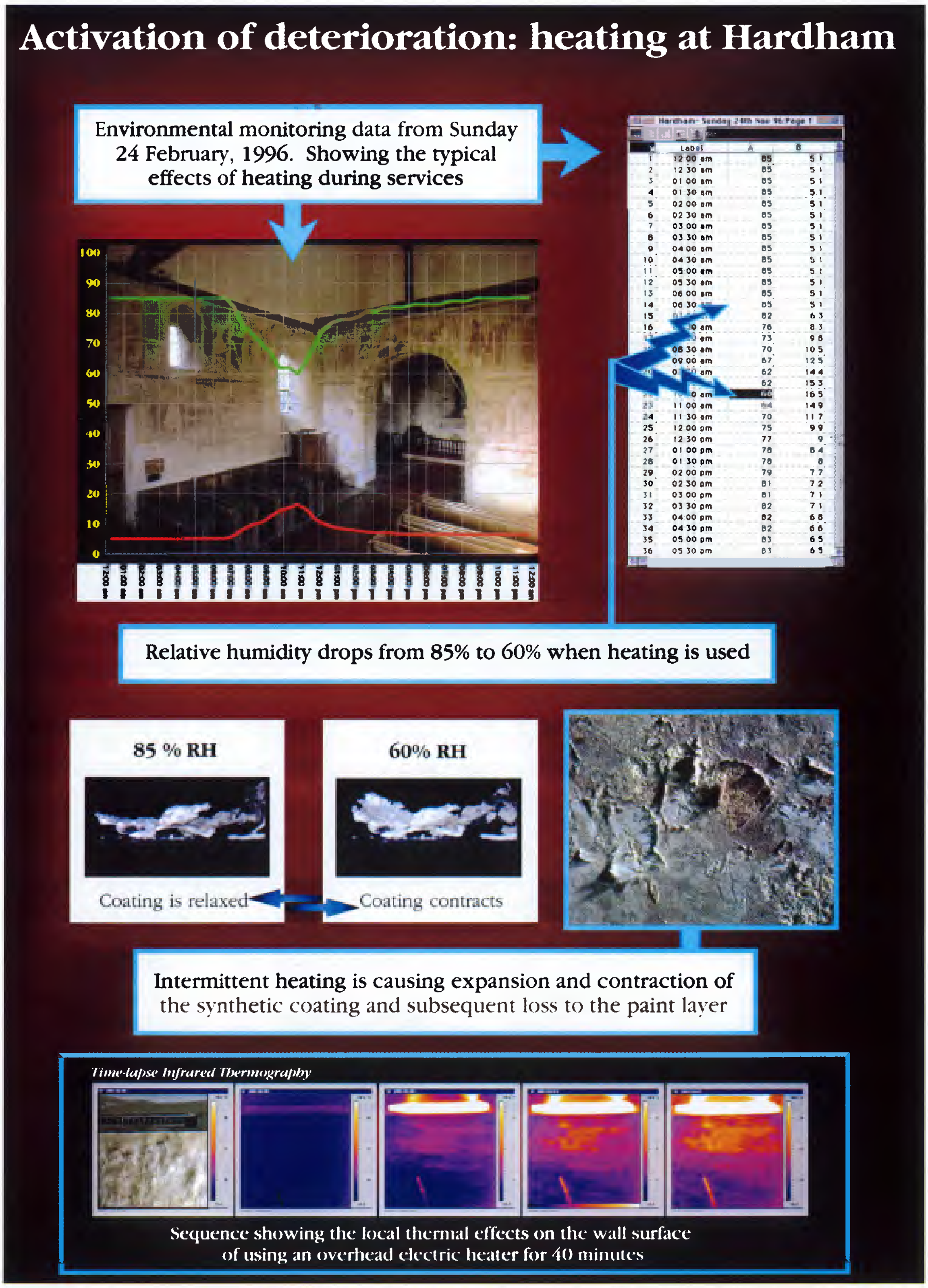

Figure 1. An Agema 489 long-wave IR Thermovision camera was used for the Hardham survey.

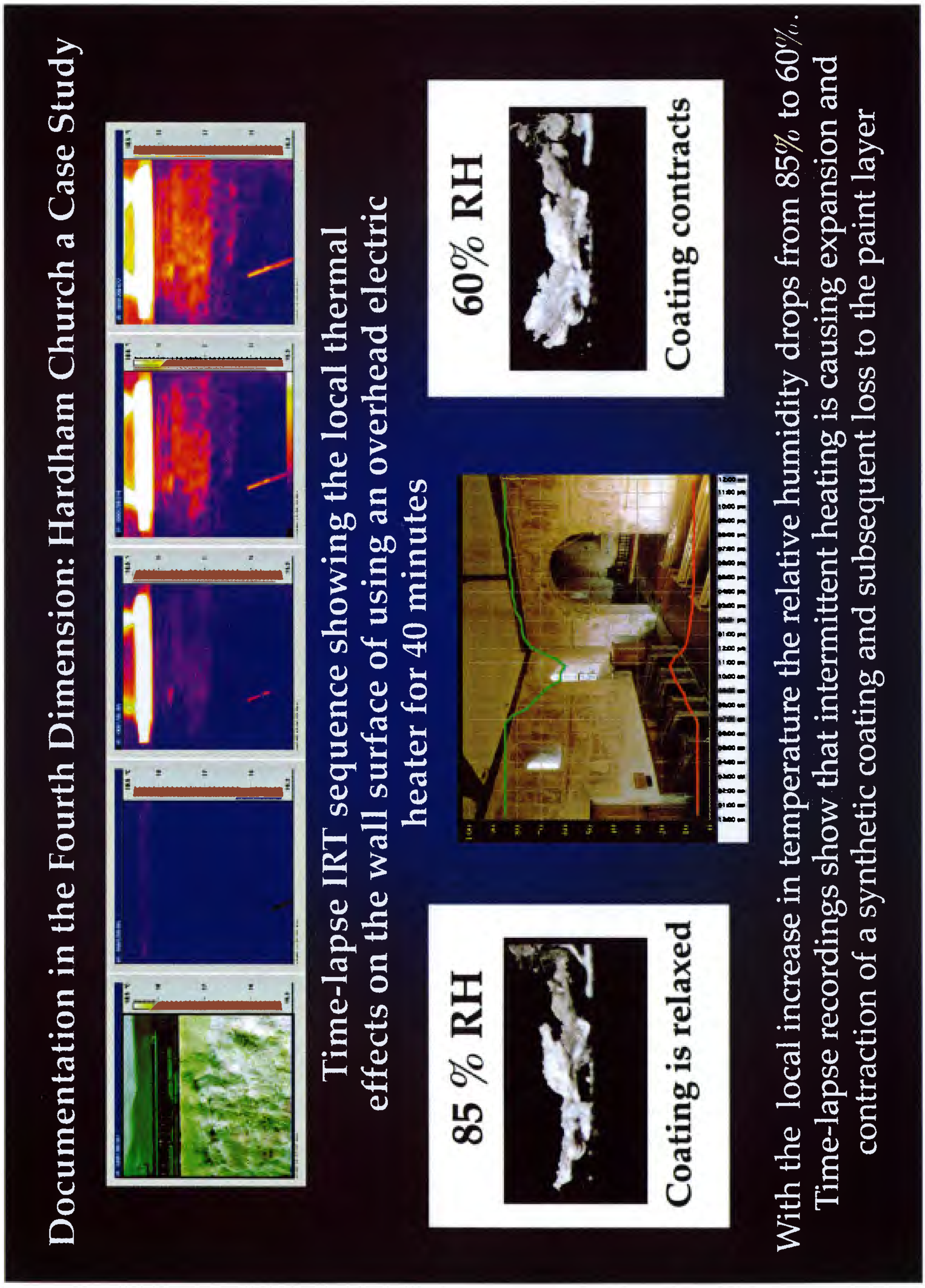

Figure 2. The images and data were combined using various programs, including Excel, DeltaGraph, Adobe Premier, Adobe Photoshop and Adobe Illustrator.

tion). As video conferencing and remote data acquisition technology is improved and becomes more widely available, it will soon be practicable to undertake remote annotated imaging – context, macro- and micro- – of sites and specific objects. Moreover, replica samples (known materials or prepared dummies) could be imaged *in situ* at the same time as the art work and under the same environmental conditions. This could yield information on how test samples behave in direct comparison to the object they are intended to simulate – thus providing a valuable link between *ex situ* laboratory experimentation and *in situ* observations.

Steps have already been made in the right direction by various bodies, and increasingly there is more money available for investigations aimed at diagnosis. However, it is fair to say that only a minority of conservators can actually offer these relevant skills. Even then, the difficult task still remains to ensure that the implications of these investigations are fully taken on board – and actually inform and influence the type of actions, and their prioritization. In other words, that we do not just pay lip-service to undertaking investigations, and then go ahead and treat the object regardless of the findings. Finally the conservator's documentation must be part of an overall long-term conservation plan that includes maintenance and inspection of the building and its wall paintings.

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9

THE USE OF GRAPHIC DOCUMENTATION FOR MONITORING CONDITIONS OF FRESCOES AND MOSAICS: THE CASE OF CAESAREA MARITIMA

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ABSTRACT

There are four major goals in this paper:
- To describe the creation of the graphic documentation for the unique Hippodrome fresco decoration in Caesarea, Israel.
- To present the use of the graphic documentation for monitoring frescoes, together with photography, registration of environmental data and daily reports for identification and description of decay problems and phenomena.
- To present the use of the graphic documentation for monitoring mosaics at Caesarea, Israel.
- To present the outline of the Cooperation Research Project between the Getty Conservation Institute (GCI) and Israel Antiquities Authority (IAA): Maintenance and monitoring of mosaic conditions in situ.
KEYWORDS: fresco; mosaic; monitoring; maintenance; base map; Caesarea; Israel.

THE PROJECT

Conservation of the fresco paintings that decorate the podium wall of the Hippodrome of Caesarea, later transformed into an amphitheatre. The amphitheatre – created around the middle of the 2nd century AD by cutting off part of the late 1st century BC Herodian structure – occupies the southern third (about 90-115 m) of the original Hippodrome.

The paintings, discovered in 1993 during an archaeological excavation directed by Dr Yosef Porath of the IAA, represent a unique example of this type of decorated surface, featuring several superimposed decorative schemes. These include animals depicted against a foliate background – the earliest and most extensive of the surviving Amphitheatre schemes – as well as more conventional panelled ornaments and other decorative schemes.

At present, more than 80 wall-metres (80 to 105 cm in height) of paintings have been uncovered and stabilized on the eastern and southern walls; a large section of the southern podium wall has been left unexcavated; and the western wall is entirely almost destroyed. Up to five (or perhaps more) successive, but discontinuous, layers of painting still remain in relatively good state; considering the short period of time during which the Amphitheatre was in use (from the mid-2nd until some time in the 3rd century), this seems to indicate rather frequent repair and maintenance of the decorated surfaces of the podium walls.

Since it was built, in fact, the local environmental conditions must have been adverse for its conservation, as the seashore is only a few metres away from the western wall.

The most important environmental decay factors are water (from rainfall, condensation and capillary transport), thermal stresses, wind erosion, water-soluble salts from marine spray, and biodeterioration.

THE GRAPHIC DOCUMENTATION – SPECIFIC PROBLEMS

At the beginning of the project, the existence of the fresco on the whole surface was not as obvious as it now. The visible surface indicated only the presence of some traces of colour and fragments of paint between many layers of plaster. Because of this, the first element traced on the base map was the outline of the plaster, and with the progress of the cleaning, the fresco design was added, using a different colour. The condition report was completed in 1998. The intervention report should be completed in September 2000, with the completion of the project.

The archaeological topography grid of Caesarea was used to situate the base maps, but we added (marked directly on the wall) more precise measurements for every metre length of the fresco.

The condition report was performed using a standardized legend for identifying the problems, with a colour code for tracing the areas with specific problems onto the base map. An English-language glossary was created by one of the conservators and used for the condition report.

During the two-year process of discovery, involving excavations by the conservators, cleaning and consolidation, we realized how complicated this project was and how quickly and unpredictably the deterioration process evolved.

THE MONITORING PROCESS

In order to achieve maximum understanding and control of the deterioration process (and factors), we began to use daily monitoring reports based on the graphic documentation, photography and personal notes. All evidence of damage was recorded on the condition report maps.

Later, when we began to use the automatic monitoring systems, the graphic documentation was connected to the photography monitoring and the remainder of the data collected (see Figure 8). We used the same method during the conservation of another fresco – *The Saints*, although the documentation process was not digitized. As it was not possible to control the microclimate in the building, it was decided to lift the fresco and transfer it to a new support for museum exhibition.

CREATION OF THE BASE MAP FOR GRAPHIC DOCUMENTATION

Step-by-step illustration of the work procedure

1. Preparation of a the Hippodrome fresco area according to the archaeological topographic grid (a 5 m x 5 m grid measured and marked on the site before archaeological digging commences). An archaeological square equals one square of this grid, where digging was performed.
   1.1 From an established zero point, the Hippodrome fresco was measured metre by metre and marked on both the site and the plan.
   1.2 The Hippodrome fresco plan was divided into 13 sections, with sequence numbers, for plotting. Every section included three archaeological squares (15 m length of the fresco wall) and was scaled 1:50 (See Figures 1 and 4).
2. Colour photographs taken with a digital camera (Figure 2). The surface of the fresco in every archaeological square was covered with at least two pictures taken by hand from close up, with about 20% overlap.
3. Import the images into the computer. Every image was imported and saved with a file name composed of the archaeological square number and the sequence letter.
4. Digital rectification and mosaicking of images (Figure 3). The images were rectified and assembled using the PhotoShop program. Initially, complete images were created, showing the fresco surface of every archaeological square. Subsequently every three were scaled and placed

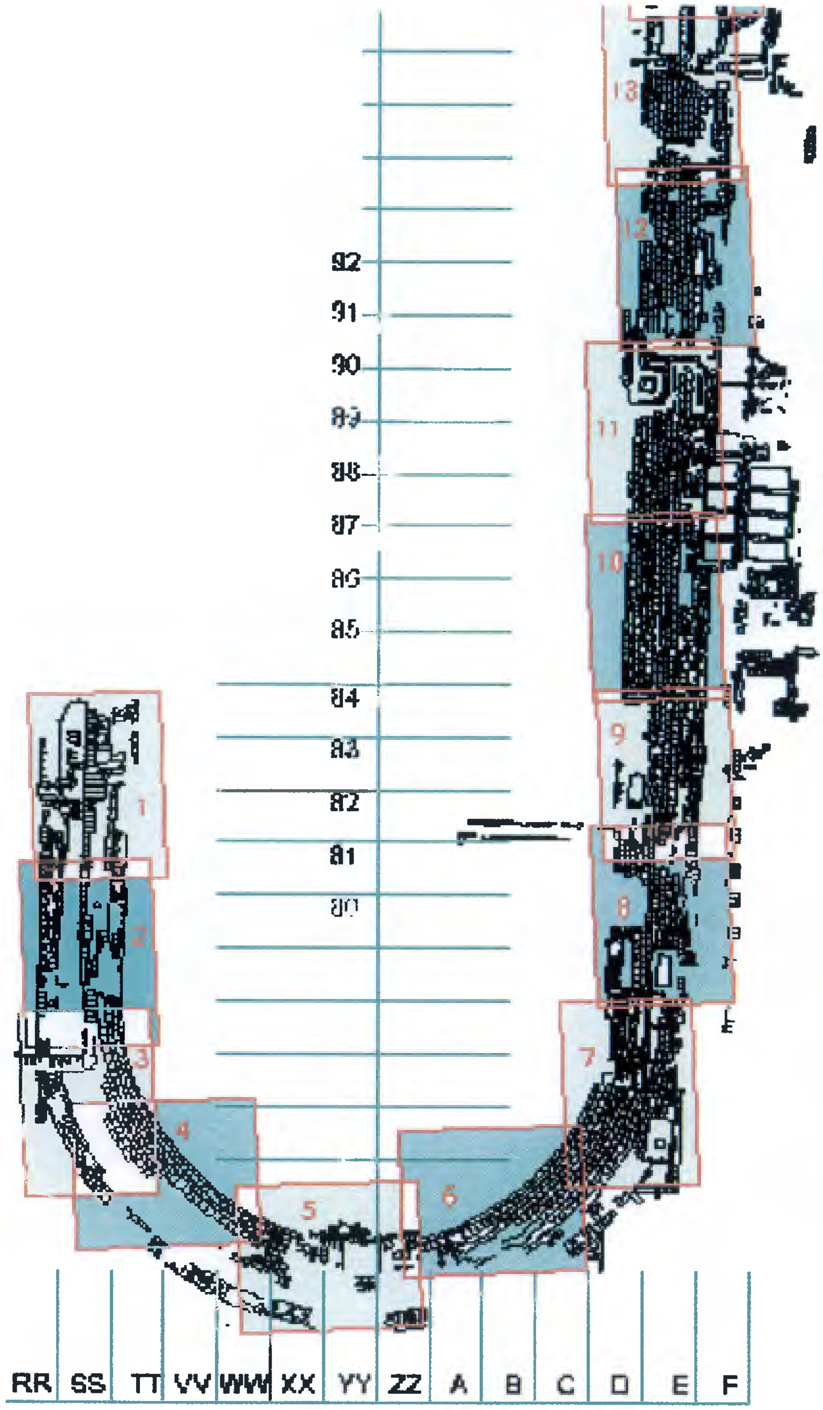
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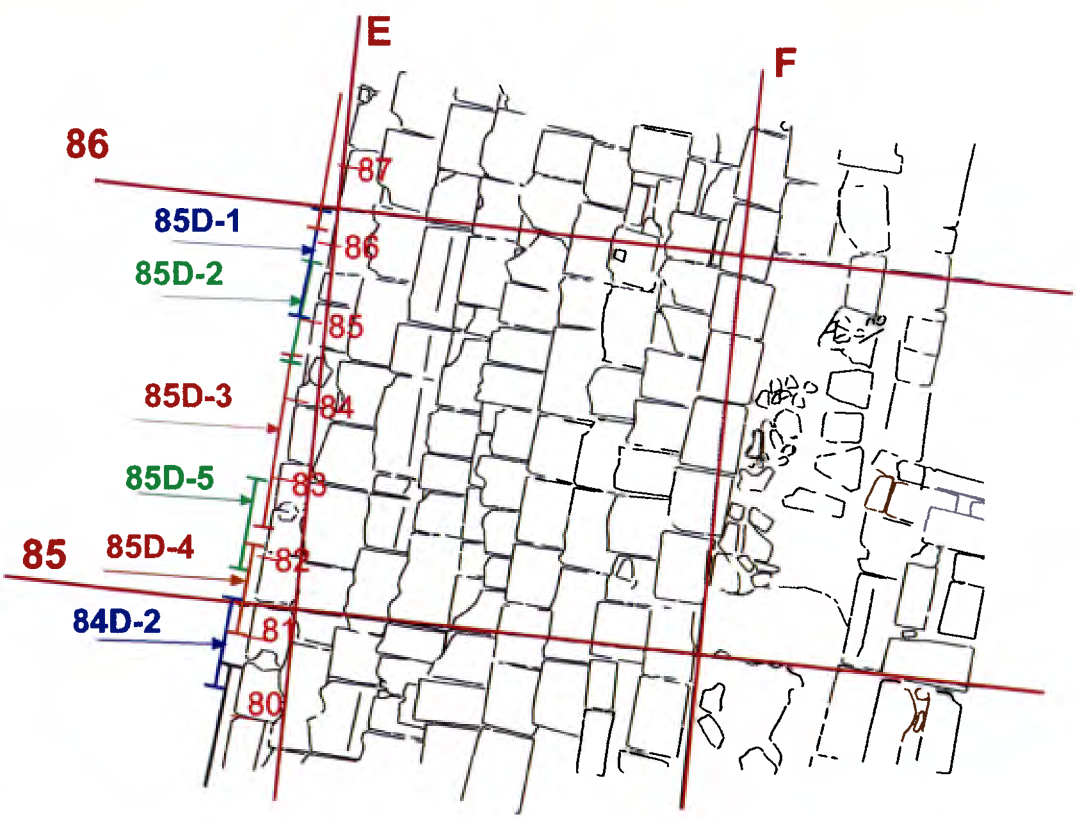
Figure 1.

Figure 2.

Figure 3.



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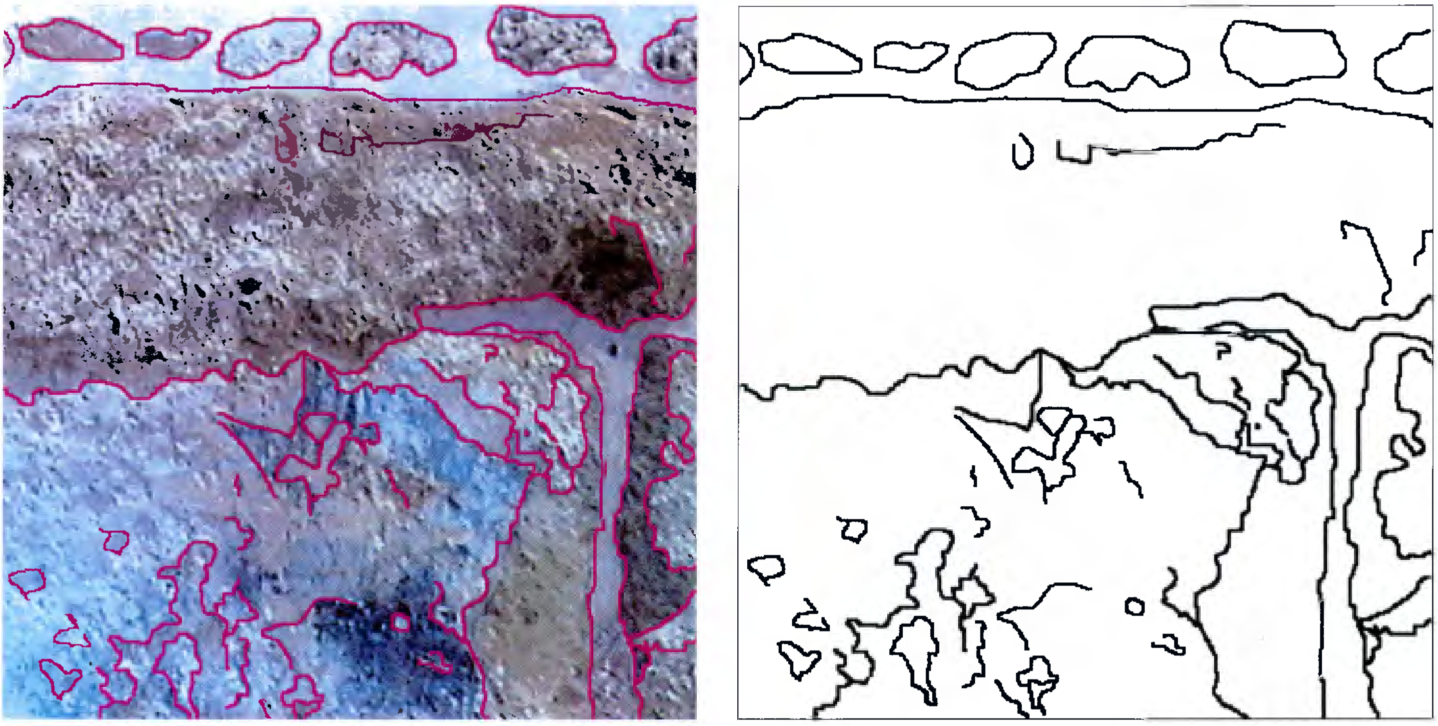

Figure 5.

according to the specific section of the Hippodrome fresco plan (Figure 4).
5. Producing line drawings of the plaster and fresco design. This was done in order to decrease the file size and to simplify the base map image. Again PhotoShop was used. Different layers were traced manually, following the outlines of the plaster and fresco design. The outlines were saved in another file without the photographic image (See Figure 5).
6. Vectorization of the raster files. This is a digital transformation that again decreases the file size. The advantage of this file format is also the possibility to change the colour and type of line. The files of outlines were imported to the FreeHand software application. After vectorization, the outlines were divided into two colours: fresco design line – red; and plaster – black (See Figure 6). This now forms the base map.
7. Use the base map for condition recording. For this work, FreeHand was also used. This application allows tracing of phenomena with different colours on different layers. The conservation information was mapped according to the Caesarea Colour Code List of Status of Conservation and Modern Intervention (See Figure 7).

USE OF GRAPHIC DOCUMENTATION FOR MONITORING MOSAICS

The conservation project at Caesarea Maritima has been ongoing for seven years. This means that we are continually obliged to maintain the mosaics, which have already received conservation treatment. The number of floors has reached 170: around 3 000 m^2.

The conservation was initially performed continuously, without planning, following the needs of the moment. Now we have created a long-term plan for the protective covering and re-burial of the mosaics. Furthermore, we have devised a planning process for monitoring the mosaic's condition, together with a maintenance plan.

It is true that the planning was done for some of the mosaics, and not for the site as a

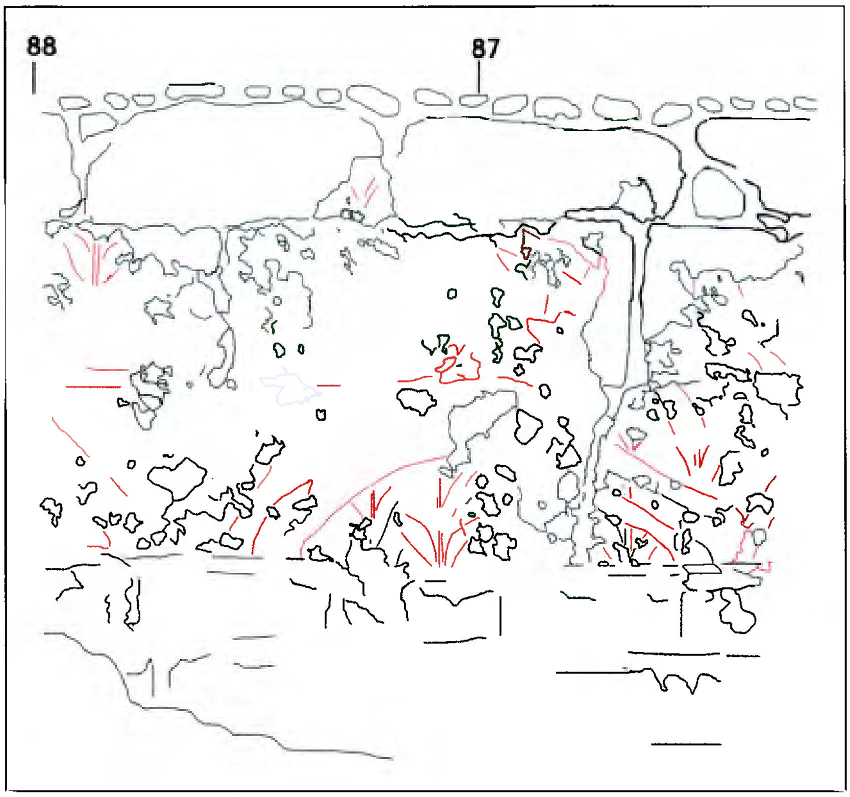

Figure 6.

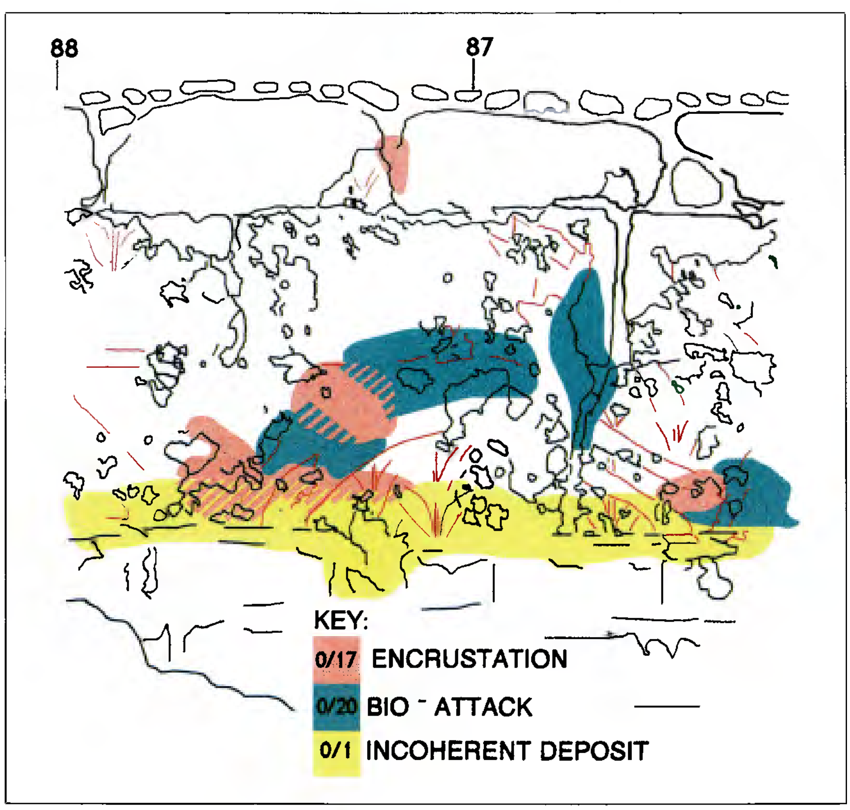

Figure 7.

whole. The scope was to estimate the efficacy of the covering and re-burial systems and to protect the mosaics from the dangerous conditions they were in. The first project was the Promontory Palace, involving protective covering of the mosaics under extremely difficult conditions. We used the condition report of 1994 to re-assess their condition in 1996 and 1999. The second project involved some mosaics in the south of Caesarea. These were re-buried in 1994 and re-opened in 1999 (See Figure 9 and Table 1). At the moment, the condition report is a part of the monitoring and maintenance card for every mosaic.

The maintenance plan is organized on the basis of regular monitoring. The operator must accomplish simple functions and fill daily or monthly report formalities. The maintenance team writes periodic mandatory condition reports using graphic documentation.

Obviously, every deterioration or change in condition must be marked on the graphic documentation simultaneously with the written reports. The repairs (if needed) will be marked according to the defined guidelines on the graphic documentation as well, but in the 'intervention' section.

The criteria for the frequency of the monitoring visits and mandatory condition report is a function of:

- The mosaic evaluation (historical and aesthetic value of the mosaic).
- The type of exposure (open air, under a roof).
- The type of protection: re-burial, surface protection (covering).
- Where the mosaic is situated on the site and accessibility to tourists (fence, open, etc.).

Figure 10 shows a sample from the database created for the Mosaics Maintenance Project.

Together with the photographic documentation, this method is accurate enough for managing the mosaic's maintenance process for huge sites such as Caesarea.

USE OF GRAPHIC DOCUMENTATION FOR MONITORING MOSAICS FOR RESEARCH PURPOSES

If the scope of the maintenance is to provide information for scientific analysis, there are other possibilities and conditions:

- The base map for the graphic documentation needs to be as accurate as possible, and the method used for creating the map would be digital photogrammetry, laser scanning or digitally rectified photography (Figure 11).
- The software needs to be AutoCAD or an equivalent program that allows quantitative evaluation of data.
- Monitoring and registration of conditions on the graphic documentation has to be done every month.
- The quantitative and qualitative analyses of the observed parameters have to be done with precise methods and instruments.

Figure 12 is a short description of the joint research project with the GCI: Monitoring and maintenance of mosaics.

The scope of the project is to study the impact of conservation treatment, combined with regular monitoring and maintenance, on mosaics in different conditions. The base maps for the graphic documentation are done using digital rectified photography (perspective controlled photography) with AutoCAD 14 software. The monitoring visits are done every month and special condition and maintenance forms are filled out each visit. Every six months the condition report (done before the beginning of the project) will be revised, together with new rectified photography and salt testing. Quantitative parameters measured during the maintenance are quantity of dust collected, time for repair, cleaning technique used, and number of loose tesserae. The environmental data are collected with an on-site automatic monitoring station. Every observation is combined with detailed photography if necessary, and mandatory overall photography from fixed points and above.

CONCLUSIONS

The methods of recording could be developed further (laser scanning, photogrammetry, etc.) and more sophisticated instruments for scientific analysis could be used to increase accuracy. Nevertheless, graphic documentation in the monitoring of fresco and mosaic processes is the medium for collecting objective and subjective information. Using this data and critical analyses, we can develop recommendations for conservation and

Table 1. Monitoring of the mosaic at locus 1440-6848.

CONSERVATION STATUS 1993	CONSERVATION STATUS 1994	CONSERVATION STATUS 1999
INTERVENTION	INTERVENTION	INTERVENTION
1. First aid: **– border consolidation** **– lacunae consolidation**	1. Full conservation treatment. 2. Surface protection: covering of the mosaic with plastic net, geotextile and sand (MO - PN - GT - SA)	1. Cleaning 2. Repair 3. Surface protection: (MO -PN - GT - SA)

guidelines for protection and preservation measures.

DESIGN OF THE MONITORING SYSTEM

- The Monitoring system of the Hippodrome fresco was built with the kind help of experts from: ICCROM; Istituto Centrale per il Restauro, Rome; Courtauld Institute of Art, London; and the National Research Council of Canada.
- Visual monitoring – on a daily basis: the Hippodrome wall was divided into three areas with a conservator responsible for the monitoring. Every day a diary is written up with notes on the problems observed. The observation is marked manually on the corresponding base map and subsequently digitized.
- Photomonitoring – on a monthly basis: from fixed points: rectified photography with a colour scale.
- Microbiological growth monitoring – on a monthly basis: visits and observation by microbiologist (identification tests if necessary).
- Monitoring station – automatic registration of conductivity (for salt content), external and internal (inside the wall) temperature and relative humidity.
- Aerosol monitoring – on a weekly basis: salt testing of exposed glass samples [10 10 cm].
- Salt testing of the rainwater – scheduled for winter 1999-2000 for three months with two aerosol traps.
- Laser scanning. For future precise monitoring of the surface, one section of the wall painting was scanned by the team of the National Research Council of Canada.

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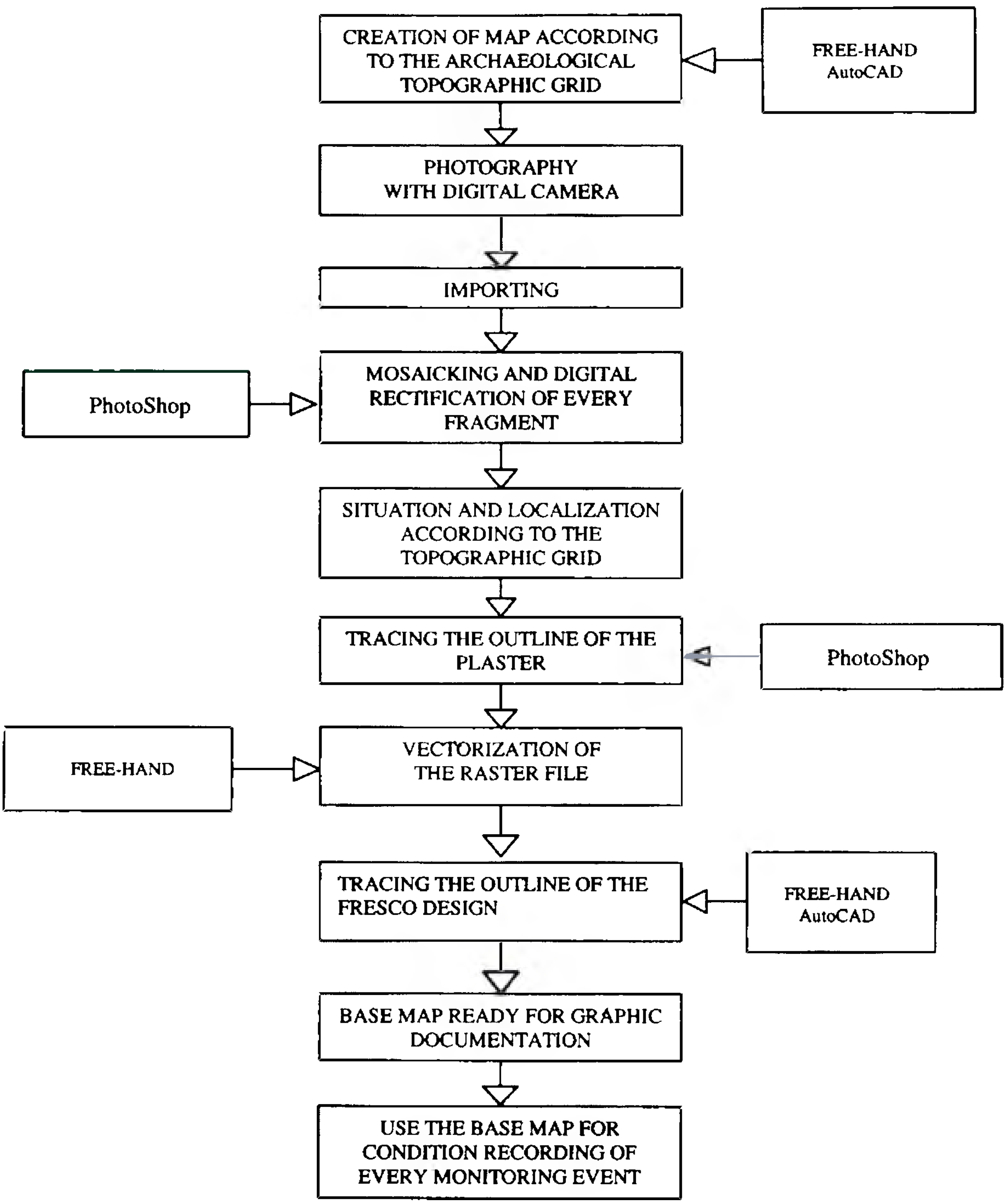
Use of Graphic Documentation for Monitoring Frescoes
Step by Step Work Procedures



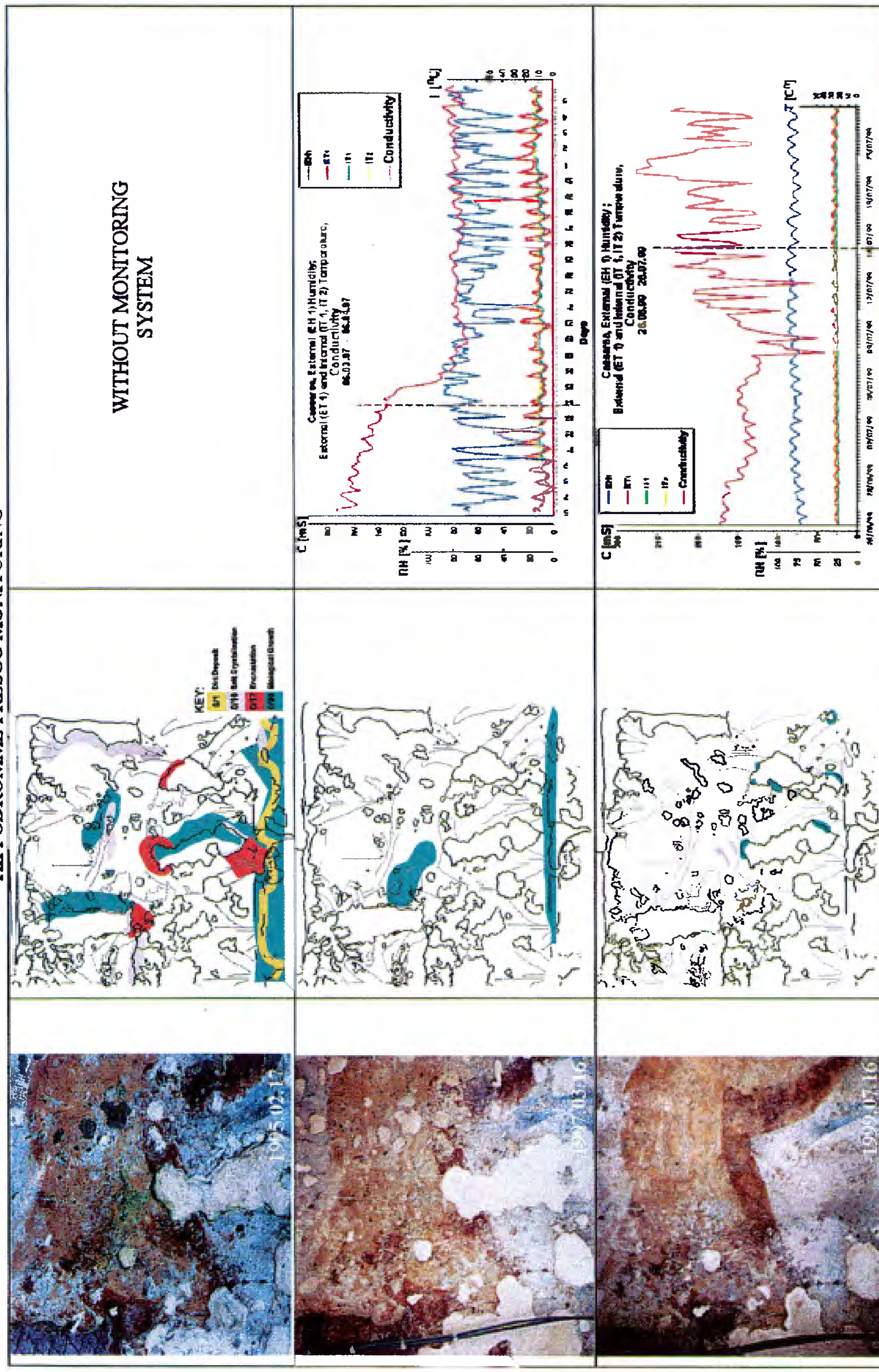

HIPPODROMME FRESCO MONITORING
WITHOUT MONITORING SYSTEM
KEY:
Conductivity
Days

Figure 8.

Monitoring of the mosaic Locus 1440- 6848

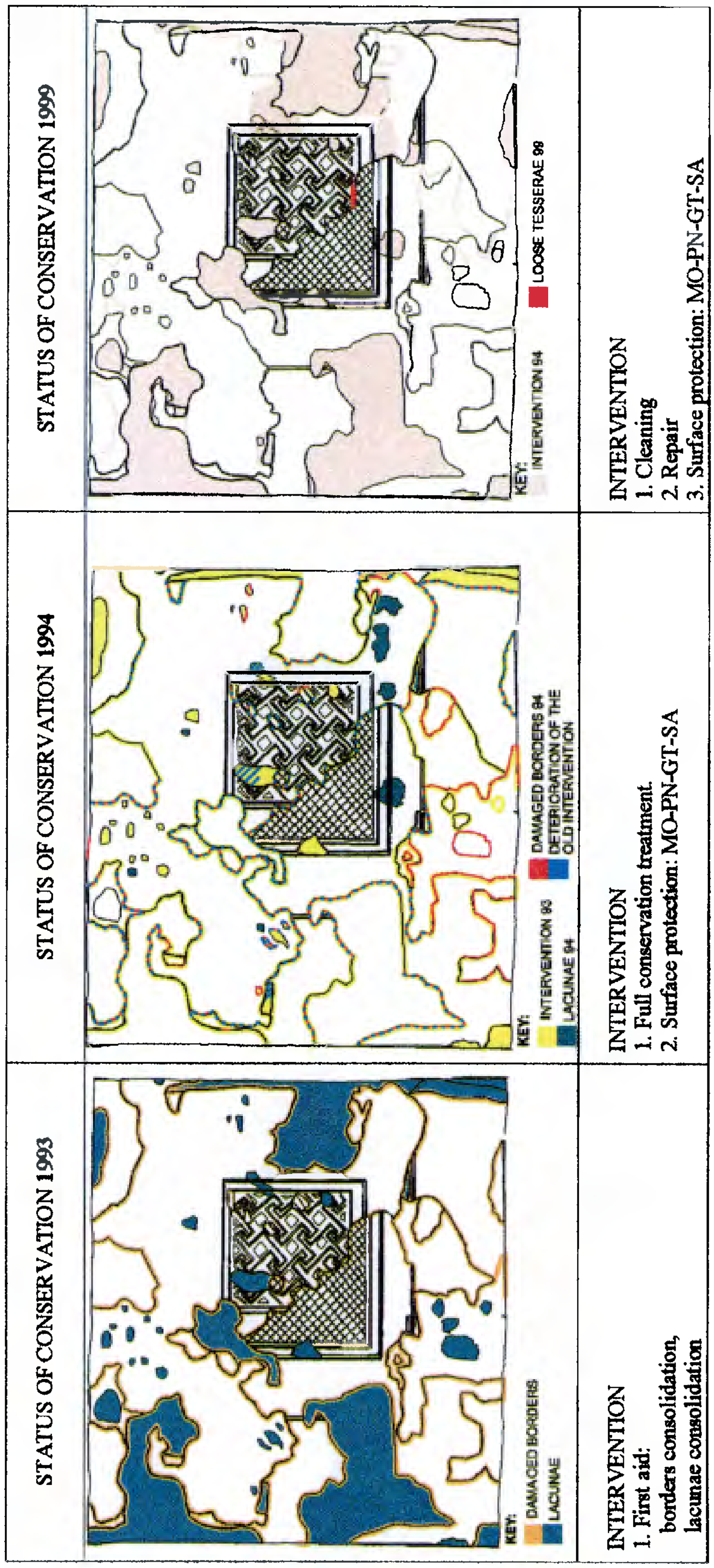


Figure 9.

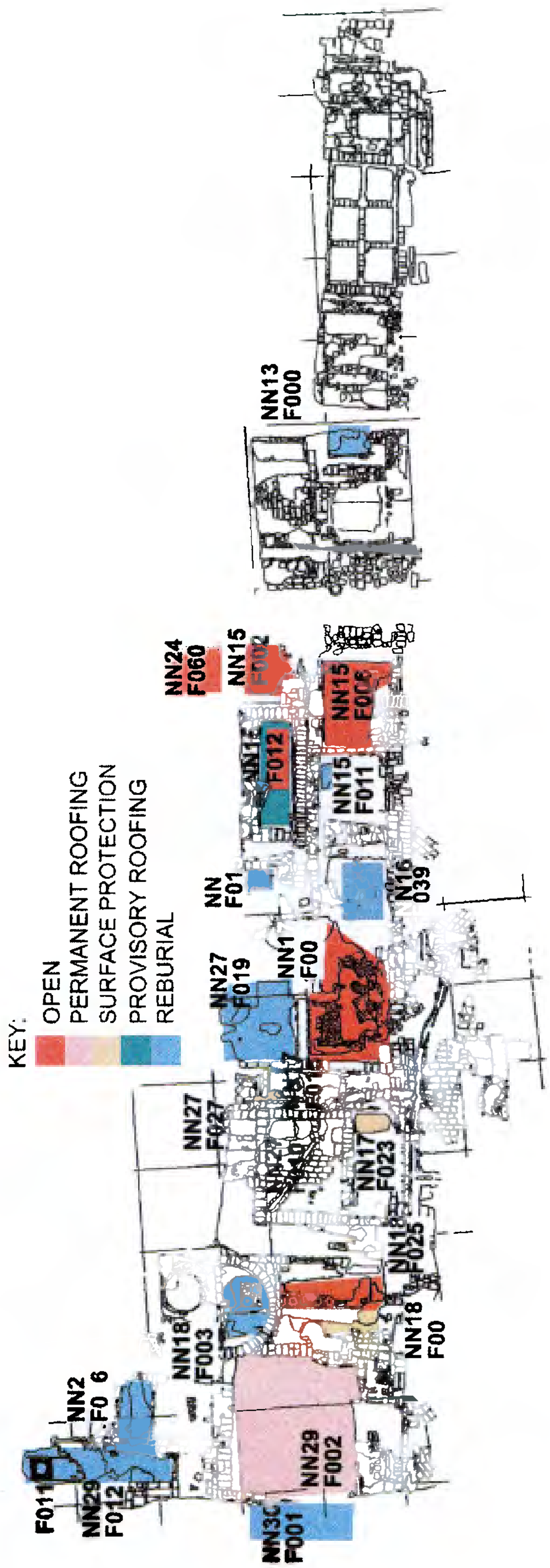


Figure 10. The mosaic floor Locus F002 is preserved 85%, evaluated as grade 2 (mosaic with simple geometrical pattern), presented to the public without shelter and needs a weekly monitoring visit by the conservator and revision of the condition report every 12 months.

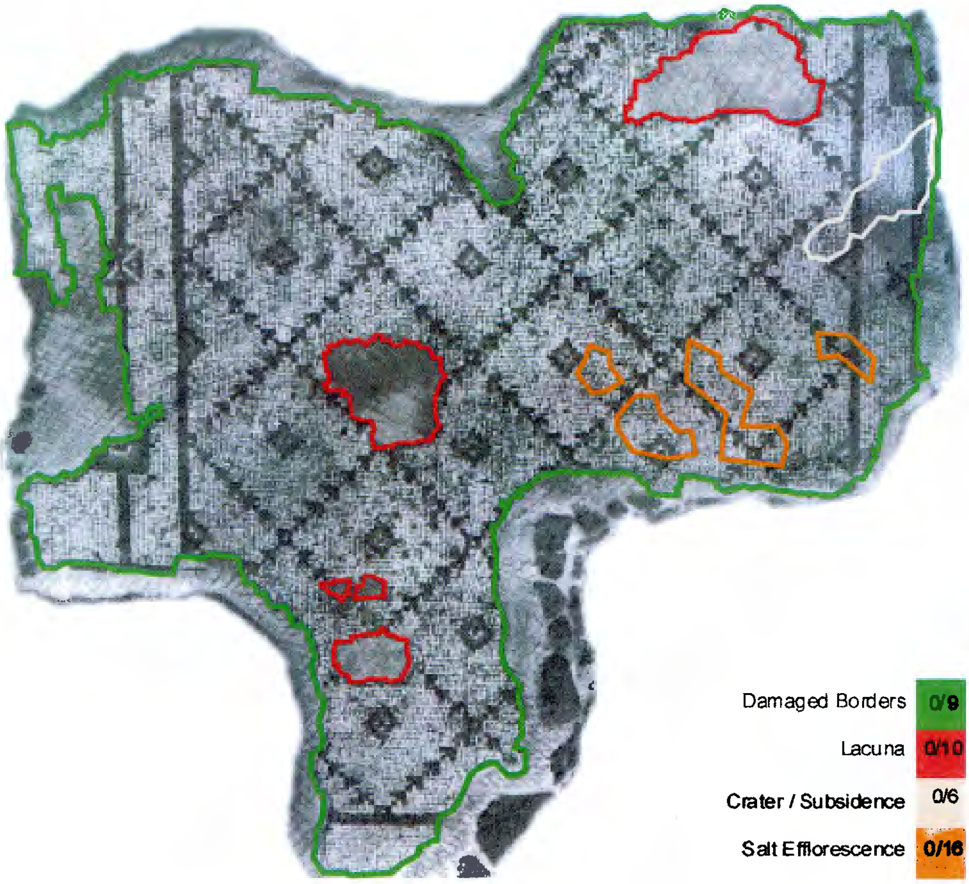


Figure 11.

Time - table for Monitoring Mosaics Research Project - one-year period

Operations	0	1	2	3	4	5	6	7	8	9	10	11	12
1.Monitoring visits													
2.Condition reports													
3.Rectify photography													
4.Overall photography													
5.Details photography [not mandatory]													
6.Salt testing													
7.Environmental data monitoring													
8.Quantitative measurements [during maintenance]													
9.Testing control samples													
10.Assessment project													

Figure 12.

10

DOCUMENTATION OF WALL PAINTING IN CHINA

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ABSTRACT

Although scientific conservation of wall painting in China started in the 1950s, the majority of conservation projects undertaken have been emergency treatments. In general, due to constraints of time, funding and human resources, most graphic documentation only serves the purpose of designing treatments. This paper provides a panorama of documentation of wall paintings in China since 1949, followed by two case studies.

One is the campaign of condition recording of nearly 3 000 m² of wall paintings at four sites in Tibet, with severe limitations of time, budget and expertise. By careful consideration of the constraints and clear definition of the purpose, the work was finished in eight days by one conservator.

The other is the extensive documentation of wall paintings in Cave 85 in Mogao Grottoes, Dunhuang. As part of a well-funded project, with international cooperative expertise and sufficient time, documentation serves many other purposes than simply for proposed conservation treatment.

The issues revealed by comparing these two cases are discussed.

KEYWORDS: China; documentation; graphic documentation; Tsa Parang; Mogao Grottoes.

INTRODUCTION

China has a vast cultural heritage of wall paintings. Announced in 1999 by the State Council, 250 further sites were added to the 500 previously listed as being under state care. Moreover, the number of sites under care of the individual provinces is about ten times this figure. Among these, about 10% were selected on the basis of the significance of their wall paintings. The Mogao Grottoes are one of these, and preserve about 45 000 m² of wall painting, spanning eleven centuries. In Tibet, there are thousands of lamaseries richly decorated with wall paintings, while in Shanxi Province there are 28 000 m² of wall paintings, distributed in ancient buildings dating from the 11th to the 18th centuries.

Scientific conservation of wall painting in China started in the 1950s. With the establishment of the People's Republic of China in 1949, by law, all cultural properties belong to the state. Several nationwide archaeological surveys were carried out in the following two decades, resulting in the discovery of a large number of significant historical sites with wall paintings as the most valuable component. Advanced techniques were urgently required to preserve these treasures. The government sent scholars and students abroad to learn scientific conservation methods. Many wall painting sites received treatments thereafter with the techniques adapted from abroad, mainly detachment. This technique was modified and developed in China so as to fit the Chinese situation. Since 1978, the country has developed rapidly, with expansion of urban areas, and construction of new railways and superhighways. This construction process exposed numerous sites. To avoid loss of valuable historical remains by such construction, by law, archaeological survey must be carried out prior to construction. Many sites were moved or re-buried, leading to a climax in the detachment of wall paintings.

In the past, graphic condition recording was closely associated with the method of detaching wall paintings and transferring them to an artificial support. Most detachment was done by dividing wall paintings into manageable pieces; this was due to the technical limitations of the method and the scale of the wall paintings themselves. Once the pieces were detached, they were mosaicked on the artificial support. Detailed documentation prior to detachment was essential for matching the pieces.

Another major field of documentation in China is for registration of wall paintings for site management. Such documentation is primarily the responsibility of site administrators, and varies from site to site and is seldom detailed, due to lack of professional documentation specialists, recommended standards and funding.

The following two case studies (in which the author was directly involved) will serve to illustrate the stark contrast between a project in which essential graphic documentation was carried out with severely limited resources and clearly circumscribed objectives (Tibet), and another in which more ambitious objectives were matched by additional resources and collaboration with the Getty Conservation Institute (Mogao Grottoes).

CONDITION RECORDING OF THE WALL PAINTINGS IN FOUR SITES IN TIBET

In July 1996, the National Administration of Cultural Heritage (NACH) organized a multidisciplinary mission to Ngari Prefecture in Tibet to evaluate the physical condition of the buildings and wall paintings, and the archaeological potential of Tuling Temple, Tsa Parang Palace (Zhada County), and the grottoes at Dongga and Piyang (Eastern Gar County), as well as the local administrative status of the sites. Because of budget constraints, the team consisted of only one expert in each discipline, two administrative officers from NACH and two from the Tibetan provincial government. The mission produced a report, based on which the estimation for conservation and archaeological campaigns was made, and the necessity of establishing a local administrative body to take care of these sites was stated. In the following year, the campaigns were initiated, and a local administrative body established.

Because of the remoteness of the sites and the poor road conditions (Figures 1 and 2), for the investigative mission only eight working days-worth of provisions for the team could be transported; therefore all the works had to be completed within this time frame. Since the wall paintings preserved at these sites – with a total area of 3 163 m^2 – are their most valuable component, the condition report would play a key role in determining the budget estimated for subsequent conservation campaigns. In addition, a certain level of detail was required to reflect the problems of the wall paintings and to design appropriate treatments. Considering the time limitations, the on-site work had to be clearly defined. Only major deterioration phenomena that would affect the conservation treatment could be recorded graphically. In order to collect detailed information on the condition of the wall paintings, a colour photographic survey was necessary as a complement to the graphic condition record. Notes were made of important aspects that could not be recorded on site, such as impressions of the condition of an individual wall painting or thoughts on its treatment. Upon the team's return, the condition report was completed using the draft graphic condition record made on site and the colour photographic survey.

Figure 1. Piyang Grottoes, Ngari Prefecture, Tibet. Overview of the site [Photo: by Jun Zheng].

Figure 2. Rear wall, Buddha's Cave, Piyang, Ngari Prefecture, Tibet [Photo: by Jun Zheng].

Figure 3. Dongga Grottoes, Ngari Prefecture, Tibet, Overview of the site [Photo: by Jun Zheng].

Figure 4. Ceiling, Cave 3, Dongga Grottoes, Ngari Prefecture, Tibet [Photo: by Jun Zheng].

Information on the dimensions of the wall paintings was provided by the architect in the team.

On-site work

The colour photographic survey was done simultaneously with the graphic recording, by taking a sequential shot of each wall. The distance of the camera from the wall was controlled by stepping on a line drawn parallel to the wall surface or by the use of a board set parallel to the wall surface as a reference. The height of the camera was kept steady. A certain area of overlapping was allowed to ensure that the entire surface was covered.

Graphic recording was done systematically through a number of steps.

1. Defining the deterioration phenomena to be recorded

Since the purpose of graphic recording was to design the conservation treatment, major deterioration phenomena such as flaking, detachment of plaster from the support, disruption of plaster, cracks, loss of plaster and surface deposits were recorded.

2. Designing the legend for recording phenomena

Considering the time constraints, the main principle for designing the legend for graphic condition recording was simplicity. The symbols should be easy to draw and readily distinguished from each other. Because all phenomena on each wall would be recorded on one sheet of paper, when overlapped the symbols should not create any confusion or be similar to one another (see Figure 5).

3. Recording the deterioration phenomena

A draft drawing of each wall surface was prepared on graph paper, and the phenomena were recorded using the legends defined. No overlay was used.

4. Making written notes of each wall

Written notes of each wall were made to summarize the conditions, to illustrate anything significant that could not be reflected in the graphic record, and to note the treatments needed for the wall painting.

Off-site work

The report was completed at the National Institute of Cultural Property. It consisted of three parts: text, graphic illustration, and photographic illustration of the condition. The text stated the significance and condition of the wall paintings, treatments proposed and estimation for the conservation campaign, with references to on-site notes, draft graphic condition records, and photographs. The graphic illustration included a scale plan of each building for indicating the position of each wall. A scaled elevation of each wall was drawn and the conditions were marked according to the draft condition record made on site, with reference to the colour photographs (Figure 6). Selected photographs were included following the graphic illustration to show the most representative decay phenomena.

The report was submitted to NACH and the proposal was approved.

DOCUMENTATION AT CAVE 85 AT THE MOGAO GROTTOES, DUNHUANG

Having successfully cooperated for ten years (Levin, 1994; Agnew, 1997), the NACH and the Getty Conservation Institute (GCI) initiated a new phase of their cooperative project in autumn 1997, to preserve the wall painting at the Mogao Grottoes (Agnew, 1999; Piqué, Maekawa and Schilling, 1999). The purposes of the project are to understand the causes of deterioration of the wall paintings, to design appropriate interventions to eliminate the causes of decay, or, if that is not possible, to reduce the rate of decay. It is also intended to train the staff of the Conservation Institute of Dunhuang Academy (CIDA) to approach the problems independently after this project by using the methodology and technologies introduced from GCI, and by jointly working together to allow conservators from other similar sites along the Silk Road to be trained and the results disseminated.

Cave 85 was selected for study because it has the most representative problems of wall painting conservation in the Mogao Grottoes. The documentation approach and methods used reflect recent developments by GCI (Eppich and Piqué, 1999) that have been adapted to the specific needs of CIDA. CIDA staff were divided into four teams: Documentation, Conservation, Analysis and Environment. The Documentation Team serves all the other teams for work involving archival and literature research, photographic survey, and graphic condition recording (Figure 7).

Archival and literature research

Establishing a chronological table listing all the historical events helps us to understand the origin of the cave and the historical events that might contribute to the present condition of the wall painting. By searching into historical texts and gathering oral history of the site, all the historical events are listed chronologically. The table is considered a living document, which can be added to and modified in the future.

Iconographic illustration of each scene of the wall painting was made to aid an understanding of the subject matter.

Historical photographs were sought to help understand the past condition of the wall paintings. By comparing the historical photographs from different periods with the present condition, active decay could be identified and the deterioration rate roughly estimated. The entire wall painting in Cave 85 received conservation treatment in 1974; by comparing the photographs taken in 1986 and 1994 with the present condition, the extent of active decay at various times became clearly defined. Assuming that the condition of the wall painting was stable when the 1974 treatment was completed, the comparison also showed that about 70% of deterioration occurred in the first ten years, 25% between 1986 and 1994, and only 5% of new decay appeared since 1994.

A bibliographic research to understand past conservation works was carried out both at the Dunhuang Academy and throughout China. Since the Dunhuang Academy has carried out conservation work for many decades and the results were well archived and published, the bibliographic research mainly concentrated on the published material that was not available at the Dunhuang Academy. In order to do this, a bibliographic listing of published material available in the Academy was made. A contract was signed to accomplish this work.

Photographic survey

A new system of black-and-white photographic surveying was introduced to the Dunhuang Academy. Prior to this the Academy had its own photographic system, but this served primarily the purpose of registration and artistic research, and in fact did not cover the entire surface of the wall paintings. The survey system introduced can serve several purposes, such as functioning as base maps for graphic documentation, allowing future comparison after treatment and future condition monitoring, and for completion of registration. A specification of the black-and-white photographic survey system was developed by GCI and was carried out in Cave 85. A total of 522 photographs were taken according to the specification. Each photograph covers an area of 120 by 100 cm, including a 10-cm overlap with the photograph each side. The space behind the central Buddha statue is too narrow for taking pictures at the normal size, so it was reduced by 50%. The walls were divided according to the specification, and a nomenclature developed to identify each photo. A label of the name together with a colour scale (see below) was included in the picture to identify it and to calibrate the colour. Scaffolding was built for the survey.

The colour photographic survey was carried out following the same format as the black-and-white survey. The main purpose was for publication and colour recording.

Graphic documentation

Detailed condition records were made using the black-and-white picture as the base map and overlays were used to record the phenomena (Figure 8). Before recording, a preliminary survey of the condition of the wall painting was made and the legends were designed for each phenomenon. The legends were printed on overlays. When recording, the overlay was fixed to the base map, and the identification of the base map, the name of the person who carried out the recording and the date were written on the overlays.

The location of the samples, monitoring probes and colour monitoring points were recorded on the overlays.

Scaled line drawings were made for each wall, slope and central panel of the ceiling and corridor. These drawings provided base maps on which conditions were marked on overlays in a summary way. Previous interventions and the active decay determined from comparison of historical photographs were also marked on individual overlays. In this way, the extent of deterioration, the intensity of decay and how previous interventions may affect the wall paintings can be clearly viewed.

Digitizing the graphic documentation

The images of the line drawings as well as the corresponding overlays of condition summary were

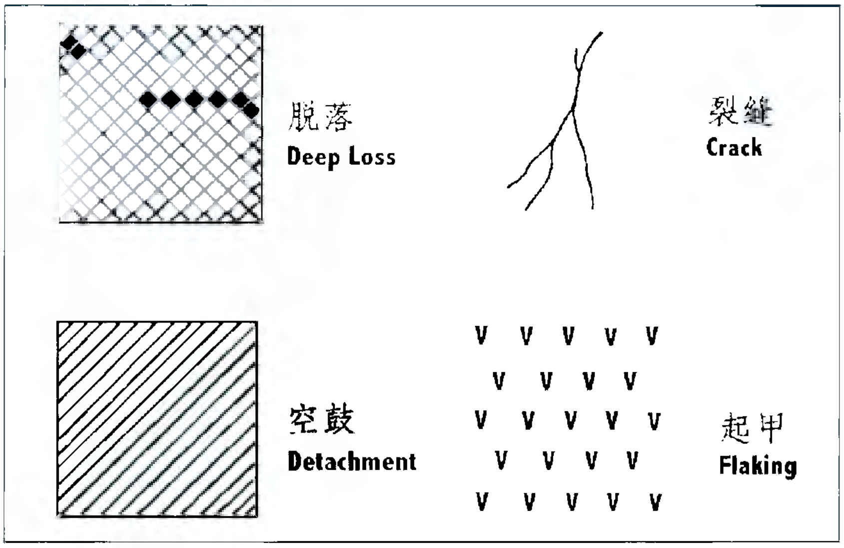

Figure 5. Example of a legend for graphic recording.

scanned into computer and vectorized (Figure 9). Separate phenomena were traced and saved on individual layers and can be printed out as necessary. A CD-ROM was cut to save the information. By copying the CD from time to time, the information can be safely stored.

DISCUSSION

Documentation must serve a specific purpose. In China, rarely is a documentation project alone approved; it has to be part of a conservation campaign or for the purpose of registration. Due to budget limitations and the great quantity of cultural heritage at risk, the policy is to rescue cultural property as much as possible. Under this policy, emergency treatment has played a dominant role throughout the country in the past, and the limited funding was preferentially allocated to treatment. Therefore, documentation has mainly served the purposes of estimating, treatment design and evaluation of the results.

The studies discussed above provide contrasting cases of documentation under different circumstances. The first is somewhat typical in China, the other is exceptional. By comparing the two cases, it is clear that the purpose defines the level of documentation but the resources available define what can be done. Elaborate documentation, especially sophisticated investigation and detailed recording, can be expensive. However, much information can be recorded inexpensively while retaining sufficient detail to serve specific purposes. Such documentation should be carried out by an experienced conservator who is familiar with the deterioration phenomena and knows well the objective. It is the conservator who is able to balance what kind of information is essential and needs to be recorded against what can be omitted when resources do not allow.

There is a growing demand for documentation in China. Awareness of the importance of documentation is not limited to conservation professionals (where nowadays documentation is an inalienable part of any conservation project), but administrative officials also require a certain level of documentation in proposals submitted and at the project evaluation stage, providing a further impetus to this trend. Recognition of the importance of documentation is reflected in the ongoing cooperative project between NACH, GCI and the Australia Heritage Committee to establish guidelines for conservation (with a working title of *Guidelines for the Protection of Cultural Property in China*). Article 6 of the draft document concerns documentation and states that “Authentic records shall be kept. Such records shall include all historic and present-day documents.” Moreover, the increasing social value of cultural heritage imposes a responsibility for higher standards of documentation on conservation professionals, while economic development makes greater conservation investment possible

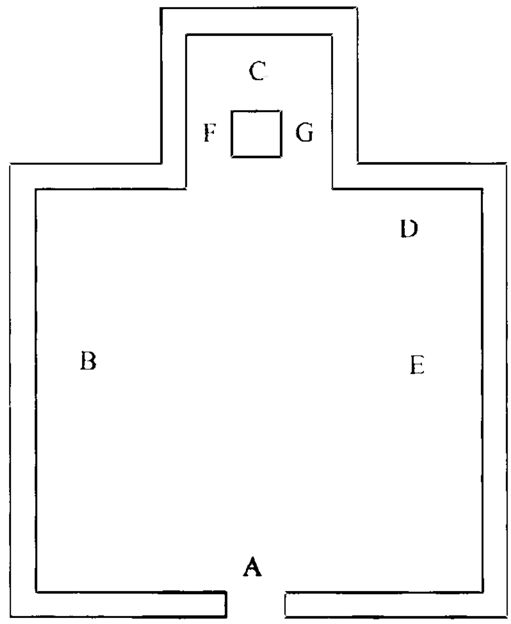

图 17 古格白殿平面示意图（ 1 ： 200 ）

Drawing 17, Plan of White Hall, Tsa Parang Palace, Scale 1:200

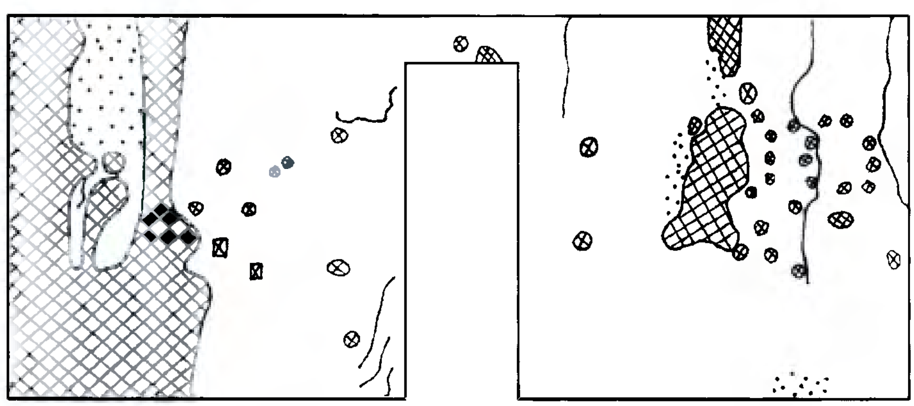

图 18 古格白殿 A 墙壁画现状示意图（ 1 ： 100 ）

Drawing 18, Condition of wall painting on wall A, White Hall, Tsa Parang Palace, Scale 1:100

Figure 6. Graphic condition recording with a plan to indicate the position of wall painting in the building.

Although developments in information storage, management, accessibility and exchange define an inexorable trend toward digitization, traditional graphic documentation will remain dominant in China for a long time. This is partly because of the familiarity of the method – it is natural for conservators to use it – but largely because of resource constraints. Cost is an important factor, as is the availability of the necessary hardware and software and the training and experience to use it. Working conditions, such as remoteness and lack of power supply, may also dictate that traditional methods are more practical in the field.

Nonetheless, standardized documentation is needed. Unbalanced development in the field of conservation and lack of communication among professionals create problems of documentation in different ways, using different 'languages' and with different quality. Defining standards can solve the problem to a certain extent. In addition, the Internet provides an unprecedented way of communication. Databases of groups of cultural property are being established in many places and made accessible on the net. Information collected by standardized documentation can be more easily input into databases, using the same format, so as to communicate with other databases or be visited from different places. Standardized documentation does not have to be highly detailed, but should record all essential aspects and information. Detailed documentation can be carried out when its objective is clearly defined.

The growing demand for documentation and the development of new techniques raise expectations of both the presentation and the function of documentation. Far more effort has to be expended than previously, and specialized knowledge is needed. Therefore the documentation specialist will become a profession in China. Although conservators in China have considerable traditional skills in documentation, the general lack of professional training in this field will impede progress. The importance and function of documentation needs to be promoted and international cooperation and communication enhanced.

Figure 7. Condition recording, Cave 85, Mogao Grottoes [Photo: Leslie Rainer].

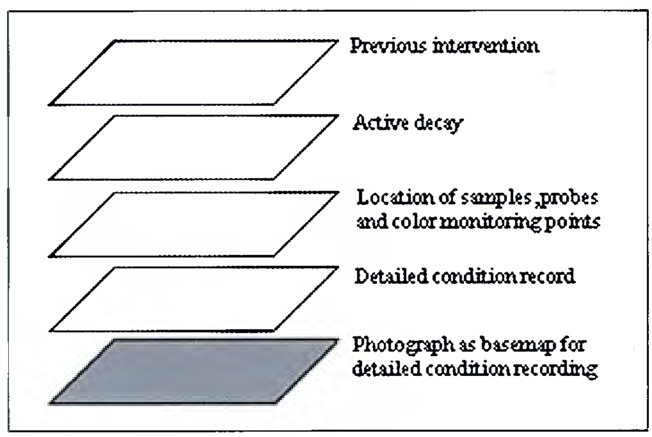

Figure 8. Scheme of principal layers of documentation for Cave 85.

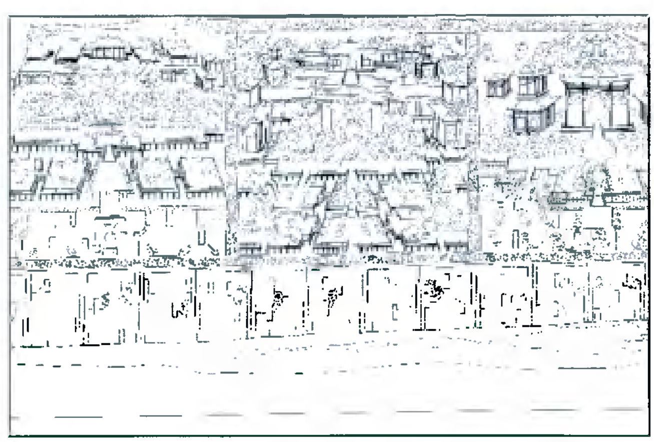

Figure 9. North wall drawing, Cave 85, Mogao Grottoes.

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The author would like to thank Sharon Cather for her valuable comments.

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11

VISIONS AND REALITIES IN COMPUTER-AIDED DOCUMENTATION FOR A PRIVATE CONSERVATOR: DOCUMENTATION IS NEVER DONE!

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ABSTRACT

The paper will describe my personal experiences with computer-aided systems in the documentation field in the last 10 years. The expectations of a conservator as a non-specialist in electronic data processing should be compared with the problems faced from several points of view: effectiveness, accessibility, data management, interdisciplinary collaboration, etc., and, last but not least, the economic implications. The development of general aims of documentation in conservation and their difficulties should be compared with visions about tools and facilities to ensure well-organized documentation – a documentation system that guarantees the best storage of all recorded data, as well as easy analysis and transmission of information in an understandable way.

KEYWORDS: documentation; presentation; software customization; mural paintings.

INTRODUCTION

This description of my experience with the application of Electronic Data Processing (EDP) to the field of conservation of mural paintings and architectural surfaces intends to illustrate its possibilities and problems for a private conservator. This contribution was not developed either from the viewpoint of an EDP specialist or that of an advanced user, but from the very personal perspective of a conservator and documentation specialist who has recognized the need and the possibility of using EDP in this domain. Although my experience might have been conditioned greatly by personal circumstances, I am convinced that the general tendencies and pitfalls of the EDP world played an essential role. Results of the documentation executed in my workshop are presented in a separate article in this volume by Rafal Szambelan, the specialist responsible for EDP in my workshop, and can also be viewed on the CD-ROM.

GENERAL AIMS OF DOCUMENTATION

The undisputed role of documentation must be perceived by mural painting conservators as a particular responsibility. Taking into account the complex situation of mural paintings, their close link to architecture and the interdisciplinary character of their conservation issues, this is a challenging task. The more conservation and restoration is seen as a scientific discipline, the more the importance of documentation grows. Documentation must definitely be considered a scientific tool, which first aims to register relevant information about the object – making it available for further processing and analysis – and finally conveys the data through adequate presentation.

OBJECT CARE THROUGH DOCUMENTATION UPDATING

In conservation of cultural heritage, the importance of maintenance versus large-scale intervention is increasingly recognized. In this context, documentation assumes a special importance, as it is indispensable as a basis for evaluating condition. In fact, effective maintenance can only be implemented if adequate observation and evaluation of condition are successfully performed. This is why the critical use and regular updating of documentation must be seen as a fundamental prerequisite for maintenance. Therefore, documentation should never be seen as definitive but must be designed for continuous expansion and updating.

CONCEPT OF COMPUTER EMPLOYMENT

Given the above-mentioned requirements, the application of computer-aided systems must be seen as a logical consequence. Developments in the EDP sector go a long way to meet documentation demands, but what is available must still be processed (i.e. adapted) according to the specific areas of application.

From this observation derives not only the issue of developing specific software or applications, but also the necessity of making meaningful use of those that already exist. These should facilitate the recording of information, as well as analytical processing and, furthermore, adequate presentation of results.

The increasing possibilities for documenting offered by EDP applications, and the dream of their efficient use to make information easier to use and access, has been an incentive for many conservators to continue their commitment in this field. However, the development, in cooperation with conservators, of customized applications based on proven software programs that would allow for significant progress must be seen as an unrealized goal.

DRAWBACKS AND LIMITS OF EDP EMPLOYMENT

Many prejudices exist concerning the application of computers (i.e. the monitor world), especially in the cultural heritage sector. This factor represents a major obstacle for meaningful further development of the employment of EDP in conservation.

It is, however, important not to lose sight of the intrinsic pitfalls, which consist mainly in a superficial use of layout options, in a thoughtless concept adoption and above all in careless additions of unfiltered information that often hide the key contents, i.e. the latter become more difficult to identify and to understand.[1]

Only through appropriate utilization, defined by the user, can a tool be employed in a meaningful way. The phrase "garbage in" "garbage out" applies as a fundamental principle in this context. Although the input and processing of information is greatly facilitated by computers, they can neither assume the task of selecting it nor replace the conceptual reflections that are the basis of any documentation project.

New developments in software and hardware continuously offer new aspects and options. Unfortunately, this progress also has a problematic side, which lies in the short life-span of these options and their never-ending renewal. Investments made yesterday are already obsolete today, and operational procedures will be different tomorrow, i.e. will have to be learned again from scratch.

The fulfilment of the desire to employ advanced information technology in the heritage conservation sector is made more difficult not only by investments in equipment and software but by correspondingly high budget requirements for basic and refresher training.

Due to the fact that documentation is still widely considered an unremunerated task of the conservator, the further development of computer-aided systems is problematic, especially with regard to the private sector.

EXPERIENCE

My own experience with computer-aided documentation has been conditioned by personal circumstances and events, yet many aspects might also be explained by general trends.

Once you get started, the temptation to proceed in this field is great, and one is confronted with a completely new world. It is a world that is far away from the classical-humanistic world of conservators, and computer-aided documentation must be seen both as a valuable tool and a well-disguised, tempting pitfall.

Getting hooked

The possibility of inputting, collecting, processing and presenting information was the first step towards my adventure in computer-aided documentation. That was already 12 years ago. From the very beginning, it brought about a close collaboration with Rafal Szambelan, a conservator trained at the Academy of Warsaw who accepted the challenge of specializing in EDP and became the documentation specialist within my workshop. The feasibility of using specific software for the elaboration of electronic climatic measurement data provided the occasion, and, as a by-product, the computer could also be used as a comfortable typewriter for producing reports.

Results soon demonstrated that we had at our disposal a fascinating and potent medium, which greatly exceeded the possibilities of traditional information processing and had to be classified as an extraordinary tool. At the same time and given the same seductive options, this tool must also be considered a highly dangerous one.

Having begun in 1988 with an IBM 256 combined with corresponding peripherals and climate measuring instruments – which can still be described as relatively simple and convenient – the temptation to use computer graphics quickly followed. The use of EDP for processing graphic information ultimately led to a technological spiral with its own considerable momentum and problems. After only two years, the desire to exploit the possibility of computer-aided mapping and the elaboration and vectorization of images led to an upgrading of hardware and software, requiring further specialization on colleague Szambelan's part. A decision was made to apply computer-aided documentation to all conservation projects executed by my workshop. While this guaranteed a wider accumulation of experience on realistic conservation sites, it also meant further substantial investment in documentation that, unfortunately, remained unremunerated. The use of AutoCAD 12 and the AutoCAD overlay system appeared to be a valuable tool which, with some skill, gave viable results and significant support in documenting efficiently. In this context, introduction of the use of GIS systems resulted in a setback, due to the sophisticated and complicated software (GEO SQL) used in connection with Oracle databases. However, from 1994 on, further progress was finally achieved with the user-friendly and also more convenient GIS software, MapInfo. Since 1996, important results have been achieved by using the ArcView GIS program.

Development and investment

The past decade has brought rapid progress in computer technology. Yet, from the standpoint of a user interested in testing his visions against reality, this progress is rather arbitrary. On the one hand lies the fascination with emerging possibilities; on the other are problems related to the investment and upgrading required.

As a result of technological developments, more and more sophisticated components are offered at increasingly lower prices. Equipment purchased with my first investments can now be considered as so much electronic garbage. Options that yesterday were unaffordable are available today for a song. This is a very positive circumstance from the current perspective, but must be seen very critically from the viewpoint of long-term investment, due to the constant escalation in terms of both equipment and training.

The question as to the right moment and the right level to start investing in these technologies is likely to remain unanswerable. The latest technologies are initially very expensive but their cost drops notably when, even after a short period, they are again surpassed by further developments. Investment in such a situation will always be a risk.

This phenomenon of rapid devaluation and obsolescence is opposed to what I consider to be valid rules for investment, i.e. to invest in better quality, accepting higher costs, in view of long-term usefulness. This desire for long-term use also corresponds to the concept of conservation, i.e. to preserve objects over time. However, our consumer-oriented, throw-away society is based on a concept of

short-lived usefulness, against which we try in vain to struggle. Computer technology assumes in this context an even more intensified dimension. Rapid development and diffusion of mass basic commodities go hand in hand with increased sales, both to new clients and to those older clients who are already monitor-dependent, in this case with the argument of unacceptable obsolescence. This spiral is hard to escape.
If, in addition, one recognizes that a large part of conservation documentation is produced by private conservators who bear the financial risk of such investments, they should at least be valid for the reasonable future. Regarding my own experience, I must unfortunately admit that I badly misjudged the technological spiral and invested too heavily in state-of-the-art technology that quickly became obsolete.

It might be useful here to summarize the main points of this discussion:

- the important fact that the reutilization of electronic data will show – i.e. pay – only in the future;
- that computer technology evolves in such a way that training, hardware and software are rapidly out-dated;
- there is a high 'deflation rate' with regard to investing in hardware and software;
- insufficient investments in training lead to waste in efficiency, time and money.

Taken together, this means that on the technological spiral all investment has to be regarded as for the distant future, less for the user of today than for those who will use the data many years from now.

GENERAL EVALUATION

The world of computers is a virtual world, which communicates through the monitor and is seen with mistrust in some parts of our society, including in the field of care of monuments. A monitor is usually associated with television, and television means show time. Consequently, the monitor as a communication medium is often intended as a show, and documentation in itself is perceived as part of it. Unfortunately, it must be admitted that computer-aided documentation is sometimes conducted with this aim.
These circumstances, together with a general reservation regarding documentation, are the main reasons for an instinctive rejection of computer-aided documentation within institutions responsible for management of the cultural heritage. The only way to combat such reservations is to use adequate arguments, i.e. facts: black on white – or even colored – but in a traditional format on paper.

Hardcopy and softcopy

If documentation is carried out via computer, it is first of all on the monitor and can then be delivered as hardcopy. This latter step has often proved to be difficult, especially if it involves the collaboration of a computer documentation specialist, who usually lives in another reality – a virtual world which has partly lost contact with the real world. Computer specialists have a virtual way of thinking in digital data units, and the concern for the hardcopy – a book, a printout – as a necessary medium for eventual information transfer is remote.
Even though the logical development in the long run will lead away from hardcopies, we still live in a world that is characterized by books, and this, in my opinion, should stay the way it is. Our generation will still find it difficult to detach itself from paper and books. The vision of a virtual library consisting of disks and tin boxes with huge backup media is, for us conservators, still rather frightening. For a broad segment of documentation users, soft copies are incomprehensible and ineffective. It will still be necessary to transmit and archive the information as hardcopy, without renouncing the advantages of EDP. Or is it simply the old, conservative notion that is hindering the new world to come – a world that is still not perceptible and acceptable for many?
The future will certainly bring change, and the next generations will be better acquainted with this medium. Hopefully, it will not be necessary to explain to them how to use a book. It appears that, today, both the delivery of all electronically processed results as hardcopy and the insertion of conventional paper documents into electronic data systems is necessary.

Compatibility

The lack of compatibility between different types of software or different versions of the same software can lead to the obsolescence and isolation of systems and eventually to the non-readability of stored data. If this occurs, the broad palette of helpful and fascinating tools – above all the possibility of continued use – is ruined. In this case, the hardcopy is the only safety net: books never lose their readability if certain rules are respected.

Data quantities

The advantages of EDP cannot be ignored: reutilization of data, processing and analysis of data, increased working speed, etc. Everything goes faster; time is saved; it becomes possible to produce more, and much more is produced. And here is the next risk: one produces far more than necessary. More storage capacity and faster processors are developed, but at the same time more data are processed and stored. Who will take care of them to guarantee their preservation and accessibility in the future? Due to the rapid development of hardware and software (frequently involving incompatibility with older versions) the archiving/up-dating of electronic data will become a seriously problematic issue for the future, which will also have a high cost.
Because of a reluctance to filter and discard data, and because of the ease of storing it, a consequence is a larger amount of similar information and a diminished possibility of finding, sorting and eventually using it. In this case, the benefits of a structure of data management that could potentially be a significant model of clarity to aid our thinking and analysis, are instead compromised.

THE EDP DOCUMENTATION SPECIALIST

The employment of computers typically implies the division of tasks between an EDP-trained documentation specialist as operator and the conservator as the one who prepares and uses documentation. The differing positions of the two are marked by the ideas (dreams and visions) of the conservator and the realities and application limits for the operator. Many hopeful notions, which in the past proved to be unrealistic given the existing level of development, were later found to be feasible. Unfortunately, it was also true that many of the results achieved could barely exit the monitor – or never exit it at all. To produce corresponding layouts as hardcopies and the necessary dissemination of the documentation to various bodies (e.g. to the client) was only partially possible and associated with notable effort.
In this regard, the issue of the often-problematic communication between EDP documentation specialists and documentation users can be seen as symptomatic.
The requisite computer-literacy training will, in the future, probably be part of general education. Yet, for a conservator today, such training means an investment of significant amounts of time and energy, which cannot be dedicated to other areas of study. The delegation of the work to a specialist seems to be sensible. This implies a risk for the conservator of losing part of the necessary confrontation with the object. This direct relationship sees documentation not only as a result but also as a process that allows the acquisition of essential knowledge.
The delegation of documentation work to the documentation specialist and the farther estrangement by the computer may result in a dangerous separation of the documentation from the object. This danger can be faced through the direct input of information *in situ* done by the conservator, assisted by a documentation specialist (see articles by G. Buzzanca and F.Piqué in this volume).
An important step in this direction is the recent development of powerful equipment that allows for *in situ* image processing, using overlay systems. The detour through manually produced documents (which the specialist must process in the studio) thus becomes superfluous. This development represents essential progress both from the standpoint of the quality of information and because one working step is saved.
The basis for graphic documentation (i.e. the base map) must be prepared adequately and is meant to be an objective and measurable reference for the positioning of graphic information. The production of high-quality base maps, which have to meet the requirement of comparability, should certainly not be the conservator's task. The use of modern photogrammetric solutions and the production of a rectified photographic basis should certainly be the aim. Nevertheless, a simple photograph in digital format is often sufficient.

THE CONSERVATOR'S ROLE

The fascinating evolution of the profession over the last decades has required conservators to develop pronounced interdisciplinary cooperation skills. Active participation in innovative developments, including new information technologies, is of fundamental importance to the conservator. Their broad application within daily conservation practice is very promising in view of obtaining usable results, because problems must be approached in a concrete way and feasible solutions have to be developed step by step.

This daily application by practice-oriented professionals and within ongoing conservation projects leads to significant developments. In this regard my workshop can already refer to numerous positive results.

The options available today on the software market certainly represent, limited only by our imagination, a satisfying array. However, essential development work will be still necessary concerning specific customized applications, which require a broad interdisciplinary cooperation to develop the necessary tools for the practicing conservator.

Also, especially in computer-aided applications, a clear definition of purpose, good planning and careful analysis of the essential functions and priorities of documentation (no matter in what form) are essential. Definition of the roles and responsibilities of the different actors involved must also be part of this process.

VISIONS

Although recent hardware and software developments already satisfy many visions and desires, they are not designed specifically for applications in the cultural heritage conservation field. So it is important to continue formulating visions, which in some cases might already exist in other fields or are not far from becoming reality. Specific applications cannot be developed without the active participation of the conservator and the definition of specific requirements.

The structure of GIS systems meets many requirements for the documentation of mural paintings and architectural surfaces. Units of non-formatted information (raw data) are filed in a specific address system and geographically referenced – the virtual architectural surface becomes our filing and reference system. Presentation issues do not have to be addressed at the beginning, because the final layout can simply call upon the raw data at any moment – an approach that is valid for both textual and graphic representations. Much discussion on symbols and terminology might be bypassed in this way.

Disputes on how a phenomenon should be named or represented would also become secondary, as the basic information (raw data) can be translated or represented, by means of layout functions, in any language or form. All comparable parameters should be processed into simple electronic information, thus allowing a maximum interchangeability and eventually a broad flexibility for individual representation. Perhaps this could also be the key for creating a system that would cross national and linguistic borders, a sort of conservation Esperanto in digital language.

Beyond these probably still remote or perhaps not so distant visions, specific applications of software programs for the field of conservation are needed. Such applications can only be developed through interdisciplinary cooperation in which the conservator plays a key role with regard to the definition of aims and requirements.

Unfortunately, the conservation community is too small to represent an economic challenge for software companies and to justify the implementation of dedicated research projects. Perhaps it is through the joining of efforts at the international level that such an initiative could be launched. The GraDoc seminar must be seen as an important step in this direction.

1 A parallel effect is the influence of EDP on the layout and especially the sheer size of conservation study projects and diploma theses.

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BEYOND CAD: A LOOK AT DATA INTEGRATION AND ANALYSIS USING GIS

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ABSTRACT

The development of low-cost, user-friendly Geographical Information System (GIS) software is making possible the use of this technology for applications that are not geographical as such, but nonetheless contain spatial attributes and mapping elements. The process of graphic documentation of decorated surfaces (including wall paintings) can be greatly enhanced by this kind of technology. While Computer-Aided Design (CAD) allows a greater drawing flexibility, GIS adds the possibilities of linking the graphic to its attribute information (so that this graphic information is not only visual or dimensional, but also acquires descriptive values), analysing relationships between 'locations,' and querying this data in complex and hitherto unimaginable ways.

The merging of CAD and GIS software applications is already happening, and this is possibly the best indicator of the success of GIS today.

The Getty Conservation Institute (GCI) is testing the implementation of a GIS-based documentation management system. The aim is to take the process of electronic graphic condition recording a step further, in order to enhance the capability of conservators to identify significant relationships between recorded conditions and the site's features, and to help them plan the conservation intervention.

KEYWORDS: *CAD; condition assessment; condition recording; GIS; graphic documentation; information management; wall painting.*

WHAT IS GIS?

A Geographical Information System (GIS) can be defined as a category of software that stores, analyses and displays various types of data with spatial attributes. This definition, however, does not convey the potential of the software for handling in a very efficient way the relationship between graphic data, its topology and its attributes.

In other words, GIS is able to act as the interface between graphics (= the base map and layers) and non-graphic information (description and evaluation of the data contained in the maps).

GIS is commonly used today not only for urban and territorial planning applications, and for transportation, agriculture, environmental and climatic studies, but also for crime response and prevention, disaster mitigation and military applications.

All these applications are concerned with relatively large areas: from a few square kilometres to entire regions. Certain applications, however, are applying GIS to smaller areas: in archaeology, to relate finds to their archaeological context, whatever the size of the project might be, and in conservation or architecture as a way to display and analyse in a more efficient and integrated way the data related to the object of study.

The range of scales of applications of a GIS is theoretically infinite. As long as a spatial component is present, there is no limit in applying GIS technology to the available data.

In the case of wall paintings and other decorated surfaces, use of GIS has the potential to fill the gap between the graphic and data components of a project, not only by bringing them under the same management and display system, but also by making the data 'intelligent.' This means, for example, the possibility of interrogating the data and displaying the results in ways that can inform the user – in this case, the conservator – concerning possible significant relationships between various types of data categories collected. Later in this paper, some examples will be provided.

GIS VS CAD: SIMILARITIES AND DIFFERENCES

The possible increase in complexity of digital data preparation and the more specialized resources (especially in terms of personnel) required for GIS data handling need to be justified in comparison with other systems, especially Computer-Aided Design (CAD). While CAD provides the capability of displaying each layer of information one at a time, or in combination, and to perform quantitative analyses (e.g. length of cracks, areas of salt efflorescence, etc.), the information still needs to be visually processed by the user.

In summary, CAD helps the conservator to carry out the analysis of the site in a more effective way, but the entire process remains a visual one.

This is where GIS provides added value. While a purely visual process is still possible in GIS, the real advantage lies in the power of data analysis of this software.

The data analysis capabilities of GIS derive from the introduction of qualitative elements of information (such as degrees of severity of cracks within the same crack layer), and especially from the spatial data query functionality of this software. In more advanced applications, its predictive modelling capability may be very useful for conservation needs. Predictive modelling is a procedure used in GIS to simulate the evolution of phenomena observed or 'predicted,' and to build possible scenarios on the basis of existing data, modified by the application of statistical models.

Queries with a spatial meaning are presented here. Only GIS provides the opportunity to answer such queries, as what is required is an integration in the drawn object of the graphic data (the 'coverage,' corresponding to the CAD 'layer') and the non-graphic data (the 'attribute,' which roughly corresponds to a field in a database record). GIS can manage and integrate both sets of data.

Below are some examples of possible spatial queries, in terms of increasing complexity (queries based on Burrough, 1986: 9):

- Where is object A? (e.g. display all the areas of flaking)
- Where is A in relation to object B? (e.g. display all the areas of flaking and their average distance from those of voids)
- How many occurrences of A are within distance D of (or contained by) B? (e.g. display the areas of flaking less than one metre from (or contained in) areas of voids)
- Which objects does this line intersect? (e.g. display all the conditions recorded that are touched by a line traced by the operator)
- Which objects are within a specified distance from this line? (e.g. display all the conditions recorded that are less than 10 cm from the line traced by the operator)
- What objects are at a certain distance from others having a certain combination of attributes? (e.g. display all the conditions recorded that are at less than 10 cm from the areas of loss where there are also cracks and the paint layer is detached)

- Create new objects from existing data (e.g. compare the areas of flaking and those of detachments and create a new layer with the areas of overlap and call it "detachment with flaking")
- Simulate the effect of a process over time for a given scenario (predictive modelling). (e.g. display the areas of paint loss 6 months and 1 year from now. This particular query needs monitoring data collected over a period of time, so that a 'time' scenario can be constructed).

A few more examples can be given at this point to illustrate these capabilities. Let us assume that the conservator suspects a relationship between cracks and detachments on a wall painting. A GIS can easily quantify this relationship, by comparing the layers on 'cracks' and 'detachments' as collected by the conservator, and providing statistical values for their association. If, for example, 85% of the cracks are found in areas of detachment, and if 60% of detachment areas contain cracks, a significant association may be present, and the conservators may thus confirm their suspicions.

Another example concerns the possibility of associating a database with a coverage. This can also be done in some CAD systems, but in GIS it is possible to interrogate this data in an efficient way and find new associations and create new coverages. If we have a database of salts and salt concentrations found on a wall painting, we can interrogate the database and select only a certain type of salt, and create a new coverage for that type of salt only. We can also ask the database to visualize the concentrations of salts according to parameters that we select. Associating a database of information that it is not spatially referenced to a coverage requires some thinking and strategies, but also knowledge of the issues that we want to explore and questions we wish to ask of a database. If we want to analyse a possible association between salt concentration and materials present on a wall, we will have to design our databases, engineer the link between the tables and prepare the queries so that the software can produce the correct answers.

In substance, while CAD has the advantage over digital imaging annotations of being able to return a metric value for the information entered (a great advantage over the abstract non-scaled image annotation), GIS adds to that the possibility of analysing information that could be perhaps suspected, but not easily measured.

AN APPLICATION OF GIS TO WALL PAINTING GRAPHIC DOCUMENTATION

GCI has applied GIS technology to the documentation of a large wall painting created by the famous Mexican muralist David Alfaro Siqueiros in downtown Los Angeles, California. The painting, in poor state of preservation due both to the experimental painting technique used by the artist in the early 1930s, and to years of abandonment and the action of weather, is now being stabilized and it will be presented to the public under a new shelter (Figure 1).

Data collection

A complete CAD-based condition record was made by GCI conservators in 1997, using laptop computers on site and mapping the condition layers over a rectified digital image of the site obtained through a direct digital image acquisition process (Figures 1 and 2) (Bishop *et al.*, 1999).

The entire graphic documentation process (excluding the digital image acquisition) took less than a month to complete, on an area 26 m long by 5.5 m high.

Several parameters were recorded, grouped under the main categories of: techniques of execution (Figure 3); previous interventions (Figure 4); and current condition (Figures 5 and 6). The graphic recording was entered on two laptops at a theoretical scale of 1:1, but in practical terms the conservators displayed areas of approximately 11 m on the screen, thus working at an approximate scale of 1:5, but zooming in when more detailed observations and recording were needed.

Other data were collected manually, in the form of annotations (sometimes entered as text on the CAD drawing), observations and detailed descriptions. Since a GIS project following the recording of the conditions *in situ* was not planned, the collections of attribute data were unfortunately not standardized, so that it is quite difficult today to generate attribute tables from these observations. Nonetheless, for the purpose of this pilot project a limited amount of data has been collated in database form.

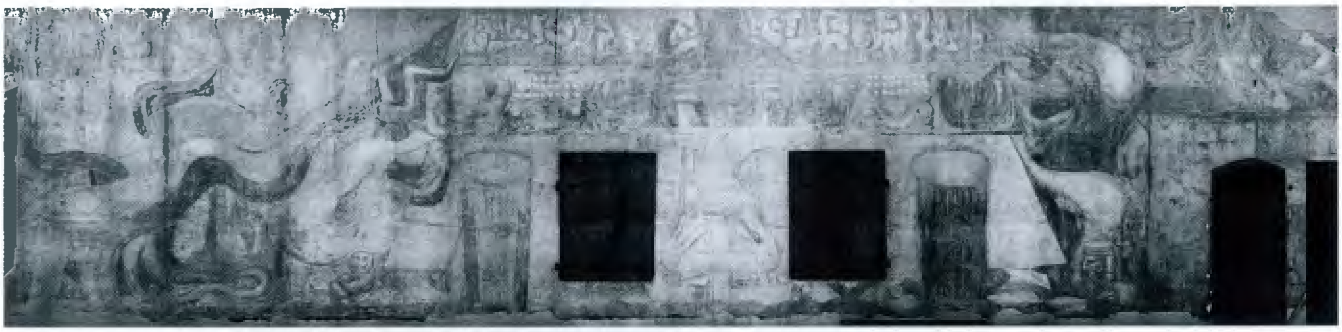

Figure 1. David Alfaro Siqueiros' mural *América Tropical* (Los Angeles), the situation in 1996.

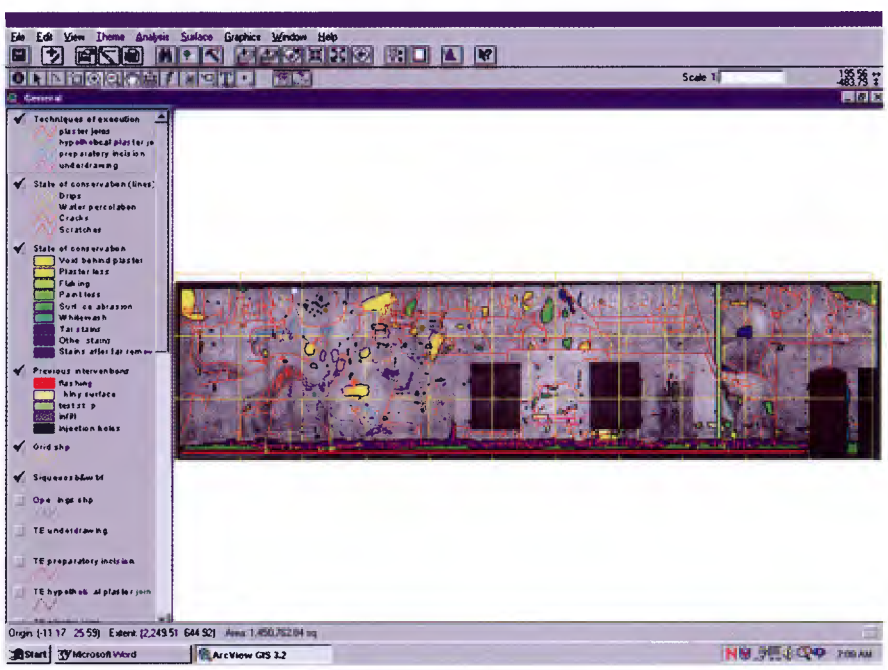

Figure 2. Graphic condition recording of the mural *América Tropical* in June 1997.
Each square = 22 metre.

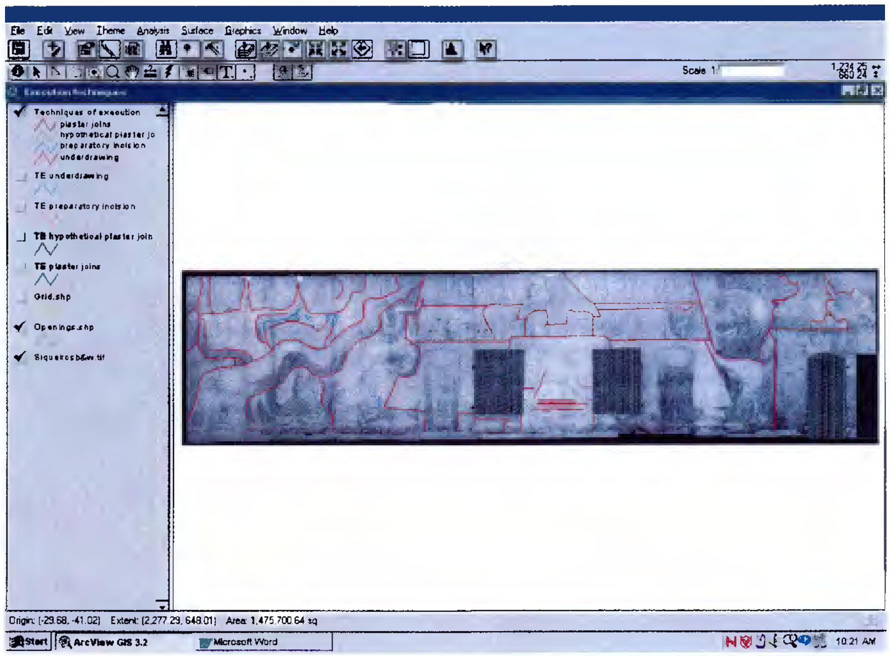

Figure 3. Recording of the techniques of execution identified on the mural.

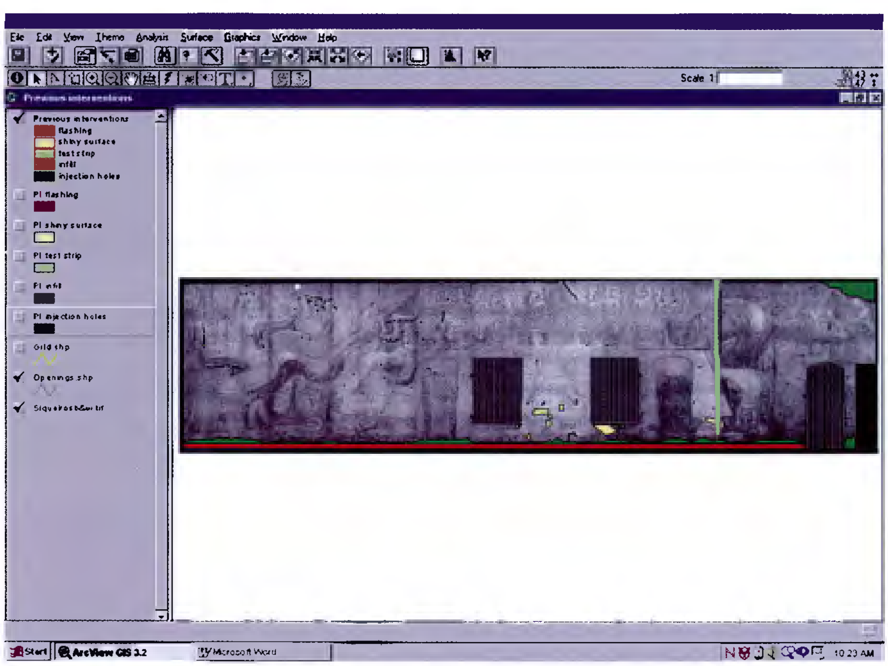

Figure 4. Recording of the previous interventions identified on the mural.

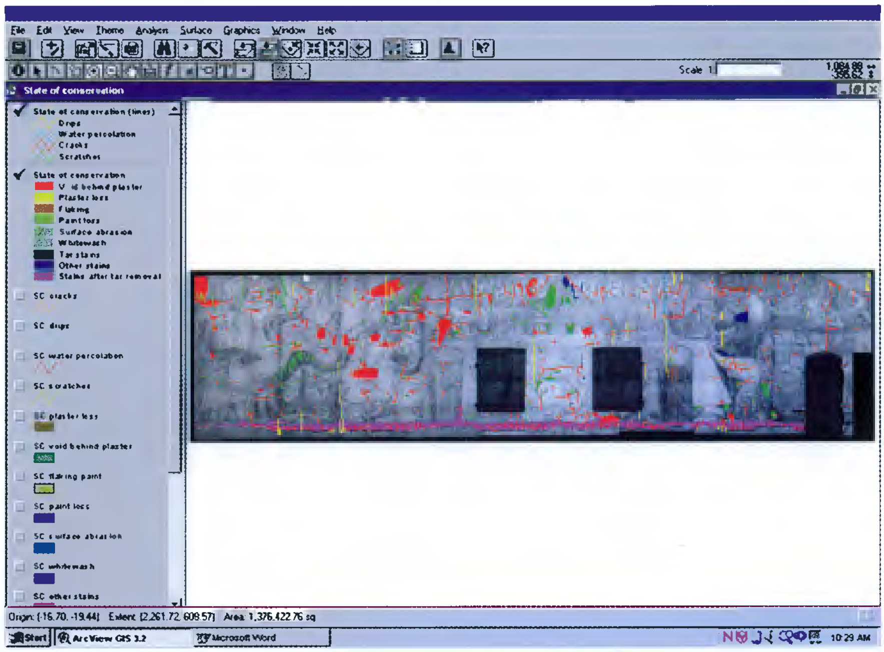

Figure 5. Recording of the state of conservation of the mural.

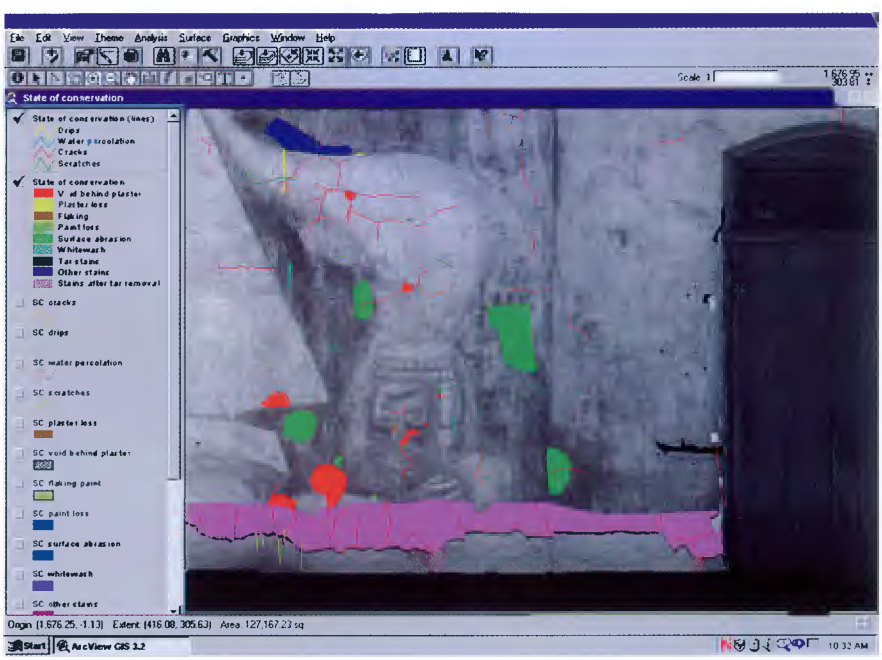

Figure 6. Detail of the state of conservation survey.

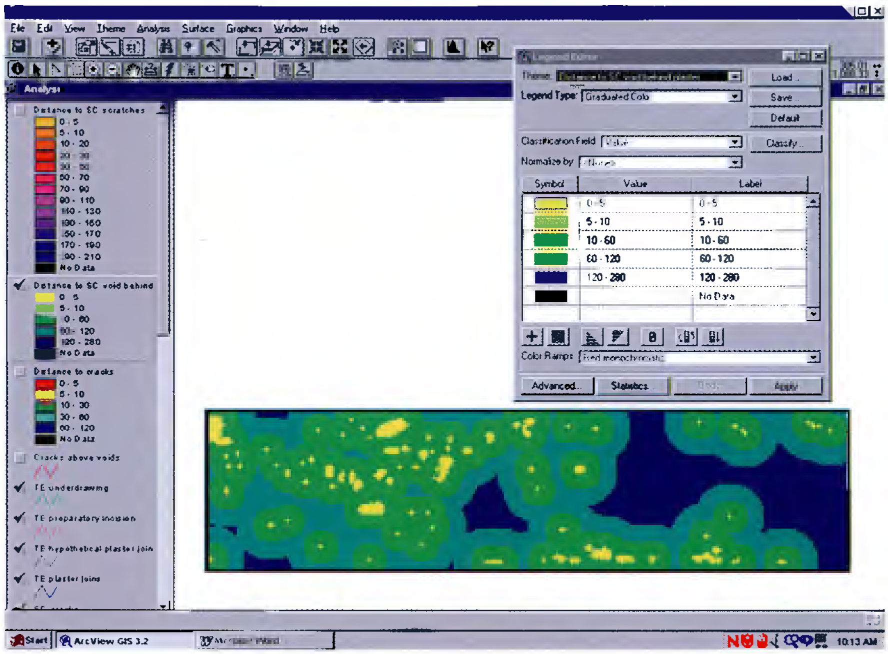

Figure 7. Mapping of the distance to the closest void under the plaster. Yellow: closest; blue: farthest.

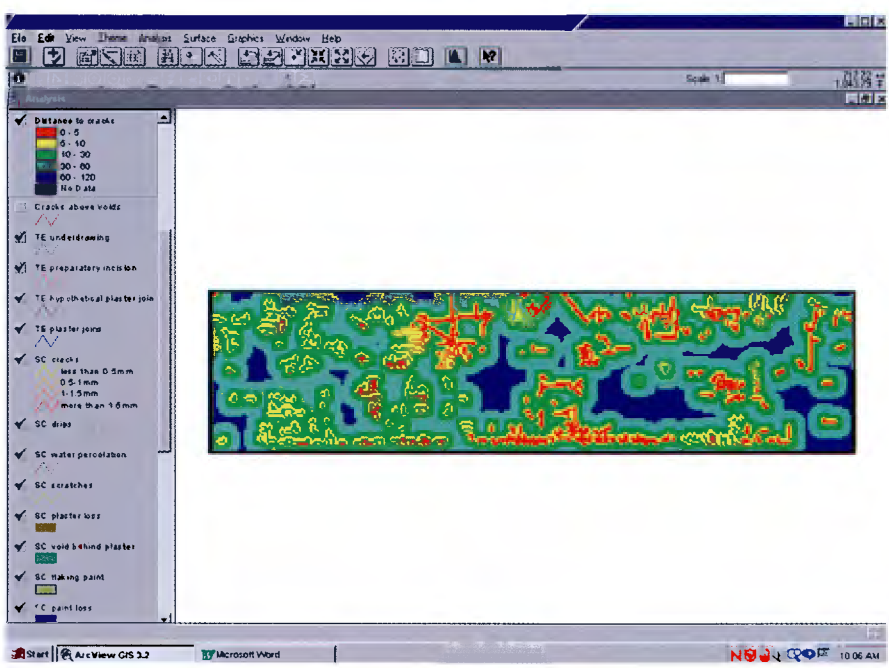

Figure 8. Mapping of the distance to the closest crack. Red: closest; blue: farthest.

GIS application
The transfer of layer graphic data from CAD to GIS is now a straightforward process. Much GIS software can read CAD, even though still not very good at separating layers (thus requiring the export of one layer at a time). The new AutoCAD Map GIS, being totally integrated in AutoCAD, overcomes this problem.

In most GIS, integration with existing database tables is also a seamless operation, making it easy to connect graphic with attribute data.

When new coverages are created ('coverages' are in GIS terminology equivalent to layers in CAD; the difference is that a coverage is always associated with one or more attribute tables), most GIS software automatically creates a basic attribute table containing a description of the layer type (point, line or polygon), coordinates, lengths of lines (if the layer is composed of lines), or area dimensions (if the layer is composed of polygons). This attribute table can be edited, with the addition of other information. If our coverage is a line coverage of cracks, for example, we may want to specify the severity of each crack by adding this information to the table. This additional information can either be numerical or text. Later, we will be able to search for and display the cracks considered 'severe' vs the 'moderate' ones, or cracks of type 1 against cracks of type 4. Using another example, if we have a polygon coverage of salt efflorescence, and if salts have been analysed, we can enter that information so that we may be able to search for the location of sodium chloride within the salt efflorescence layer. Note that in this latter case one can have more than one type of salt present in the same area. In this case, the data cannot be entered in the original database, since each record (in this case, each area of salt efflorescence) can only have one element associated with it. The solution is to create a table of 'salt types' and enter them there. The table will comprise the type of salts identified, accompanied by a unique identifier (usually a numerical identification – ID) that corresponds to the same number in the original table of salt efflorescences. This number identifies one, and only one area in the coverage. Linking the two tables through this ID number allows the search done in one table to display results in the other. Thus, in this example, using one table you can display all the areas where sodium chloride is present, and using the other you can display only one area (or a group of areas) and see how many different salts it contains. The potential to perform proximity analyses (such as distance to void, or distance to cracks, Figures 7 and 8), is another advantage of the system.

The pilot project applied to Siqueiros' *América Tropical* mural has served the purpose of evaluating the process of data conversion from CAD to GIS, and of verifying the type and amount of supplementary data needed to make the GIS operation effective.

GCI is now in the process of establishing a set of protocols to facilitate this transition and to check for possible technical obstacles along the way.

BEYOND CAD: A STEP-BY-STEP APPROACH
GCI is convinced that spatial graphic databases will be the most common type of data structure within the next few years, especially if one accepts that, according to recent statistics, 70% of all data that can possibly be conceived has a spatial component (Oracle GIS seminar, Los Angeles 1998). The fact that GIS is now being integrated in CAD packages, its effective way of providing spatial queries, and the possibility of also integrating other types of data, such as text and images, makes it an ideal tool for conservators, who thus can have at their fingertips the entire project, from photographs to plans, and from text documents to databases, all linked to the graphic condition record.

The following is a step-by-step approach to the building and use of a GIS for a conservation project, perhaps an ideal scenario, but nonetheless one that can be tested in real cases.

1) *Definition of aims and scope* This step will take stock of the resources available for the documentation and assessment project, and establish the sequence and methods of documentation, including:
- definition of the scale of recording,
- definition of the method(s) for collection of baseline data (photography – analogue, digital or both); rectified photography; simple photogrammetry; complete photogrammetry (with various degrees of precision); laser scanning; or a combination of methods),
- establishment of the legend for graphic

condition recording, and
- establishment of the database for the collection of non-graphic data. In the GCI system the database is prepared in Microsoft Access.

2) *Collection of existing documentation* Based on the importance of the data collected, some of it may be scanned and used in an image archive of the site at different periods. More important survey or photographic data may be converted into vector files (survey) or geo-referenced (photographs), so that it can be built into the GIS and be part of the time dimension of the database.

3) *Collection of baseline data* This is the part of the project that deals with the preparation of the base map of the site. As mentioned above, one or a combination of methods of varying complexity may be used. Based on the resources available and the importance of the site, this can be anything from photographs taken by the conservator team and rectified in the lab, to full-scale photogrammetry or laser scanning. Its final result must be a digital raster or vector file, scaled to a 1:1 dimension, upon which the on-site conditions will be recorded.

4) *Graphic condition recording* This can be done in a variety of ways, ranging from manual annotations, but over copies of the base map prepared in step 3, printed to the scale decided in step 1, to annotation over the basemap, directly on the computer. No matter what method is used for the primary collection, it is recommended that AutoCAD be used for the layering of the information. GIS software is not as flexible as CAD in its drawing features.

5) *Non-graphic condition recording* Forms reproducing the data entry interface of the Access or other database are printed and distributed to the conservator team so that they can fill them at the same time as the *in situ* graphic condition recording.

6) *Data editing* Possibly every evening, and certainly while still on site, the data must be edited. Graphic data should be checked for accuracy, if collected directly on computer, or scanned, converted into raster format, and placed over the base map in their appropriate layers, if collected manually. Non-graphic data must be entered in the database.

7) *Laboratory data editing* Back in the laboratory, the data must be re-checked, and minor adjustments may be made. This is also when a first draft printed copy must be made.

8) *Conversion to GIS* The layers prepared in CAD must be converted to GIS-compatible form in order to acquire the functionality described above. AutoCAD Map does not require any conversion, but the more complex queries described above may not be possible using this software. Many other GIS software suites are also able to read and display CAD files, but not to attach databases to them, or further separate layers as needed. The conversion process is simple and requires a few minutes to complete. A little more complex is the linking of the databases to the newly-formed coverages. The organization of a GIS for a conservation project still requires specialized technical personnel to create the necessary attribute tables and database links. Training will be required for all conservators to enable them to use the GIS system. Especially in the first phases of a project, they might be helped to overcome the impact of the new system by the use of user-friendly and project-specific interfaces, which will need to be prepared by the GIS experts assisting in the project.

9) *Analysis* During this step the coverages are compared and various combinations of coverages may be created in order to confirm or refute specific theories on causes of deterioration and the evolution of conditions of the site under investigation. This step can help substantially the

final condition assessment, where the conservation recommendations are formulated.

CONCLUSIONS

In this rapid expositional discussion of GIS features and their possible applications in a project for condition assessment of a mural painting, the author has tried to demonstrate that a GIS is the logical evolution from a CAD-based process of graphic condition recording. CAD adds to the visual analysis of a condition record the capability of quantifying those conditions, in terms of linear distances and total area. On top of that, GIS adds spatial querying functions and attribute analysis capabilities, transforming visual analysis into a more objective process, facilitating the planning aspect of the conservation project. The extra cost in terms of software components, and especially technical human resources required and the cost of training for conservators, is compensated by the advantages of having an integrated and powerful system of data analysis at hand.

As a result of experience with the introduction of CAD as the basic system of graphic condition recording at GCI, it is clear that practical demonstrations, hands-on training on the general features of a new software suite (one- or two-day training modules usually suffice), coupled with daily work using the software with the assistance of experts, are often sufficient to give the conservators adequate familiarity with both software and procedures. Continuing practice and the application of the system to different projects finally provide the opportunity to test it in the field and transform it into an essential tool. The same will happen with GIS, once the conservators experience its features at first hand. How fast this will be adopted, however, ultimately depends on the capability of conservators and documentation experts to work together and understand each other's needs, limitations and motives.

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13

MURAL PAINTING DOCUMENTATION AS A SPATIAL DATABASE

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ABSTRACT

How can one accomplish mural painting documentation in a more effective way? Can the use of information technology save the conservator's time at an affordable cost? When creating the graphic documentation, the mural painting conservator acts just like a surveyor. If so, why shouldn't the conservator use the same technology as the surveyor? The non-graphic part of mural painting documentation naturally underlies the graphic documentation. When creating it, the conservator acts just like a geographer. Therefore, why shouldn't the conservator use the same technology as the geographer? These are the main ideas on which the method presented in this paper is based.

Practical applications are presented and illustrated, based on current mural painting conservation projects.

KEYWORDS: *mural painting; conservation; GIS; graphic documentation; spatial database; rectification; architectural photogrammetry.*

1. GIS AND MURAL PAINTING DOCUMENTATION

Due to the great similarity between the surveyor's current activity and the conservator's activity in graphic documentation, we tried to take advantage of the technological progress in geo-technologies (digital cartography, digital photogrammetry, remote sensing[1] and geographical information systems (GIS) in order to accomplish mural painting documentation in a more effective way.

These fields are rather young – approximately 30 years – as their operational application depends on the availability of graphic hardware and software facilities. It is worth mentioning that geo-technologies, despite their relative youth, are already mature and widely spread in all practical everyday applications that naturally involve geographic information. Huge spatial databases based on digital maps and satellite or aerial imagery are under construction and in operational use. These spatial databases are designed to integrate heterogeneous information from different sources, having different formats and operate in complex computer network[2] environments. In this context, a special mention must be made of the MARIS (*Mappa RISchio*) project developed by the *Istituto Centrale per il Restauro*, Rome, Italy (Accardo, 1998). Nevertheless, these technologies can be easy and effective to use, provided that the GIS specialist is in close co-operation with the conservation team for properly adapting them to mural painting documentation problems. For example: specific coordinate systems[3] must be defined instead of geographic coordinate systems; proper graphic descriptions of the mural painting ensemble must be achieved, especially for hidden areas or for those regions that do not have planar developments.

Traditional (manual) methods of achieving mural painting graphic documentation do not imply high positional accuracy.[4] The graphic recording or mapping of the deteriorated areas is based on conservator's examination and interpretation. Of course, this process is subjective and the conservator's responsibility is high. Hopefully, future technological progress might offer appropriate sensors that will provide relevant data for assisting the conservator in this type of work. Actually, 'non-destructive testing' (e.g. IR and UV-based techniques) is a current research topic in the conservation of works of art. In any event, the use of image processing techniques, which are currently used for remotely sensed data interpretation and classification, would be valuable.

Nevertheless, there are cases when positional accuracy is very important. In this context, photogrammetric techniques are required: "The application of this technique (i.e. photogrammetry) to mural paintings will prove to be valuable whenever a highly accurate record is required, for instance, to verify the possible movements in a building, or to determine the precise state to be re-established after the transfer of a painting" (Mora *et al.*, 1984, p. 28). Moreover, according to Ferri (1986) "There are more and more examples, over recent years, of the use of photogrammetry in the survey of artworks and, now that scientific research in this field is nearly complete, this technique is well on its way to becoming a normal, everyday, practical procedure." In this context, let us remark that, fortunately, digital photogrammetric software systems are already commercially available and, according to the current trends in this field, their cost is going down.

2. Initial goals

From the beginning, the main operational purpose of the proposed method was to reduce the conservator's effort dedicated to graphic documentation of mural paintings.

In the following, the most important issues the authors initially took into account and the reasons behind them will be presented.

First, ease of symbolizing and symbol manipulation was required. The conservators do a lot of work in symbolizing deterioration and treatments. This is especially true for areas that have to be reported with raster symbols (e.g. dots) or hatching. Moreover, in traditional handmade surveys, once a specified pattern symbol has been chosen, it is very difficult to change it because this practically means making a new map. The same is true when corrections are needed for larger areas that are symbolized with raster/hatching.

Second, avoiding the subjectivity of the traditional handmade 'graphic basis' (base map), which consists of a line drawing interpretation, was another important issue. The authors' purpose was to create a graphic reference basis which must stand also for an objective support for thematic recording (deterioration and treatments) ensuring, at the same time, greater accuracy of the survey. Such a graphic reference basis is a photo-document and it will also be used during future conservation works, enabling ease in detecting change and considerable reduction of the conservator's effort.

Third, better accuracy in locating and describing the deterioration and conservation treatments. This issue is one of the most important in graphic documentation of mural paintings and would be extremely valuable for conservation works over the years to come: better accuracy in thematic recording will ensure better conservation decisions.

Fourth, graphic documentation display at various (convenient) scales was required. Additionally, the specific symbols the conservator chooses to use must be scaled altogether with the graphic reference basis and all the other thematic records.

The fifth issue consists in the need for flexible overlay capabilities between the graphic reference basis and various – ideally, any – combinations of thematic layers. The overlay process must not imply additional effort in re-creating the graphic reference basis as it does in the traditional (manual) approach.

Sixth, the method must be used easily by a conservator and should not imply any special professional computer skills. In other words, the conservator must be allowed to focus on the specific conservation activities and not on sophisticated computerized tools.

Last but not least, the cost issue: the method must induce a cost comparable to the traditional approach. Ideally, off-the-shelf software and hardware have to be used.

3. Digital surveys of mural paintings

The proposed method, called 'mural painting digital surveys' (Murariu and Petrescu, 1999), consists mainly in applying GIS technology to the specific problems of mural painting documentation. GIS technology was chosen because it naturally provides the software functionality required by the authors' initial goals (i.e. image rectification,[5] digitizing and descriptive data processing). Moreover, the required software functions are currently implemented in various types of commercially available GIS software. At the same time, this technology ensures ease of integration with other classes of software, which are relevant and useful in cultural heritage: digital photogrammetric systems, image processing, computer-aided design (CAD), desktop publishing,[6] relational database management systems[7] (RDBMS).

Mural painting digital surveys consist of three components: a graphic reference basis (base map), thematic mapping layers (thematic component) and descriptive components (tables, texts, images). These components and the way they are achieved are presented below.

The **graphic reference basis** is a rectified digital image and, consequently, represents a photo-document of the mural painting. The input digital images may be scanned photographs or digital images captured with a digital camera. Although the "3-3 – Rules" (Waldhaeusl and Ogleby, 1994) referred originally to the reconstruction of 3-D objects and scenes, their application is useful and strongly recommended, taking into account, at the same time, the specific conditions and requirements of the mural painting conservation problems. The rectification is carried out using digital techniques, by means of specific software functionality. The image is rectified in the wall-based coordinate system. In this way, the conservator can perform graphic recording and measurements at a scale of 1:1. Whenever possible and appropriate, several subsequent operations may be applied to the rectified image such as: image enhancement,[8] contrast stretching,[9] and classification.[10] Image acquisition, image conversion in digital format and digital image rectification may be also performed by specialized personnel under the coordination of the mural painting conservator. Creation of a graphic reference basis does not exclude the use of more accurate photogrammetric techniques whenever required.

The **thematic mapping layers (thematic component)** can be points, lines and polygons. Usually, the creation of this component is the conservator's task. The conservator creates points, lines and polygons directly on the screen having the rectified image as background. This process is called on-screen digitizing and is a common GIS function. Of course, the points, lines and polygons are used for recording the deterioration areas and the conservation treatments. The use of automated techniques (e.g. image processing, pattern recognition) for assisting the conservator during this process is recommended, where possible and appropriate.

The **descriptive component** includes mainly specific attribute[11] data, usually organized in tables, which are relevant to the mural painting conservation but may also include any other type of digital information, which naturally supports the mural painting conservation process (e.g. photographs, texts, databases). For instance, specific attributes attached to polygonal zones may be: area, type of deterioration, type of conservation treatment, and so on. In the case of lines, for example cracks, one can include the length and type of crack as attributes. For points, such as injection points, the type of substance injected and the corresponding injected quantities may stand for attributes. It is important to remark that the method does not impose restrictions on either the number of attributes or their type. Thus, various kinds of photographic and video data (for example general views of the monument and macro-photographs) can be also considered as attribute data. Moreover, relevant documents converted in digital format (e.g. scanned documents), text files (e.g. written reports, historical studies, conservation methodology, technique of execution, treatment information, condition, description of conservation problems, previous investigations), meteorological and soil information, and laboratory tests may also be attached as attribute data.

It is very important to note the close relationship[12] that exists between the thematic component and the descriptive component. For each thematic layer – be it composed of points or lines or polygons – there exists a corresponding table that is automatically assigned to the layer. (For the sake of clarity we will consider throughout this paragraph that the thematic layer consists of points only.) This table is initially empty and can, eventually, become the descriptive component of the layer. It is the 'user' (in our case, the conservator) who will decide this. If the decision is 'yes' then the table will have as many rows as points in the layer, and as many columns as 'attributes' (characteristics) the conservator will choose to describe. For instance, let us suppose that the layer is dedicated to 'injection points.' Then, each point in the layer corresponds to an injection point on the wall and, for each point, there is a corresponding row in the associated table. Let us further suppose that the conservator is interested in recording (among other things, that is 'attributes') what type of substance was injected in each point. Consequently, a column will be defined within the table and that column will be named, for example, 'injected substance.' The next step is to load in each cell of the column what substance was actually injected at the corresponding point (row).

Therefore, the method results in a spatial database that integrates image, thematic mapping (graphic) and descriptive information. It is important to note that integration of these different types of data is naturally ensured by the use of GIS technology.

Originally, we intended to use the method for solving the graphic documentation problems only. Nevertheless, when putting it into practice we realized that the outcome (i.e. the spatial database we created) was in fact a 'skeleton' which systematically structured all the information related to the conservation process. Thus, the method can be naturally extended in order to include the entire mural painting documentation.

4. Practical application: the Monastery of Bistrita (Bolnita), Romania

The Monastery of Bistrita (Bolnita) is one of the most important mural painting monuments in the southern part of Romania. The mural painting was done in Byzantine 'afresco' style and dates to the 16th century (altar, narthex) and 18th century (exonarthex). This unique jewel represents the only mural painting monument completely preserved in its original form in this part of the country over the centuries. The conservation problems are generated by the severe deterioration (exfoliation, salts) and, in many areas, by the imminent danger of losing the pictorial layer. An emergency conservation project was required. Therefore, a limited amount of time was available for documentation. The conservator adopted a scene-oriented acquisition approach, whenever possible. Thus, for each wall (east, south, west, north) of each room of the church (altar, narthex, exonarthex) several shots were taken, each shot generally corresponding to a particular Byzantine style/tradition scene. For instance, the western wall of the narthex was covered by 4 photographs: 1) the founders of the church, 2) St Constantine and St Helena and 3-4) the Transfiguration.

The emergency mural painting conservation project for the Monastery of Bistrita was approved by the National Commission of Historic Monuments within the Ministry of Culture of Romania.

4.1. Graphic reference basis

During the image acquisition phase, some control information was prepared in order to ensure the subsequent rectification. In this respect, two scale bars were used and several distance measurements were performed between identifiable locations of the mural painting. The shots were taken using approximately the same distance and homogeneous illumination. A Canon SFTb camera was used.

The graphic reference basis (see Figure 1) was created having scanned photographs as input.

The scanning resolution was fixed at 400 dpi, according to the required centimetre accuracy.

For rectification purposes, coordinate systems were chosen such that photomosaics and collages would be possible. Thus, 6 coordinate systems were established, corresponding to the following architectural parts of the church: 1) altar, 2) narthex, 3) vault of the narthex, 4) exonarthex, 5) vault of the exonarthex, and 6) exterior of the church. For example, the coordinate system for the narthex (without the vault) had the origin in the lower eastern corner of the southern wall; the graphic reference basis of the narthex consists of a collage of 20 rectified photographs which cover the 4 walls of the room: southern wall (6 rectified photographs), western wall (4 rectified photographs), northern wall (6 rectified photographs) and eastern wall – Triumphal Arch (4 rectified photographs).

Due to the presence of two wooden beams, hidden areas were encountered on two walls (south and north) of the exonarthex. For these hidden areas, the conservator decided to combine the graphic reference basis (i.e. rectified photographs) with a manually produced line drawing, outlining in this way the hidden graphic features of the wall painting. This line drawing was accomplished by the conservator herself using the graphic functionality of the GIS software, by superimposing it onto the areas corresponding to the beams. Thus, the homogeneity of the data structure was secured.

Due to the emergency character of the project, the conservator decided that image rectification should be performed exclusively for those areas where typical deterioration phenomena were encountered. For all the other areas, a general outline of the walls was digitized. This situation was encountered in the exonarthex where the lower part of the southern, western and northern walls had a few pictorial layer areas preserved. Thus, rectified photographs were practically useless, because such a photograph would include very poor information. Instead, the conservator replaced the rectified photographs with a manual line drawing using the graphic functionality of the GIS software. This line drawing stands for the graphic reference basis of the corresponding wall areas.

4.2. Thematic component

The thematic component (see Figure 2) was introduced via on-screen digitizing having rectified images or a general outline of the walls as background (exonarthex). This component describes the geometry of the condition, each theme corresponding to a mural painting deterioration phenomenon. The mapping of phenomena was exclusively carried out by the conservator.

4.3. Descriptive component

Descriptive (tabular) attribute data (see Figures 3-4) were attached to several themes presenting the state of conservation. This will be further completed during the worksite conservation activity and final documentation phases. The attribute data were useful whenever thematic data were displayed because they provided a simple and natural way of categorizing and symbolizing. Thus, for each exfoliation area (which is a polygon from a geometrical point of view) the conservator created an attribute whose value described the type of exfoliation encountered. As a consequence, the legends of the thematic maps dedicated to exfoliation phenomena were established based on the values of the corresponding attributes in the tables. This process is assisted by the functionality of the GIS software.

It is important to note that both the area and perimeter of polygonal regions and length of line features can be automatically calculated and stored as attributes.

Also, several scanned photographs were incorporated as detailed descriptive information attached to particular mural painting areas.

A 3-D simulation related to the mural painting from the vault of the exonartex was performed and its results were also attached as descriptive information.

4.4. Hardware and software

A common PC computer platform was used: Pentium II 366 MHz, 64 MB RAM, 6 GB HDD, Windows NT 4.0. Scanning was performed using an Epson GT-6500 scanner. Additionally, a HP DeskJet 870 Cxi printer was used.

The GIS software used consisted of ESRI's ArcView GIS 3.1 for Windows, one of the most popular desktop GIS platforms worldwide, along with two of its extensions – ArcView Image Analysis and ArcView 3-D Analyst.

ArcView Image Analysis functionality was needed for image rectification and other specific image processing techniques. Additionally, ArcView 3-D analyst was required in order to achieve a 3-D simulation of the vault of the exonarthex. All the other tasks were carried out using the core ArcView GIS 3.1 exclusively.

5. Final remarks

The method proposed in this paper is applicable in most cases of mural painting conservation and it proved that low-cost GIS software systems can also provide appropriate functionality in order to achieve graphic documentation of mural paintings. Thus, mural painting digital surveys can become a common and practical tool for the conservators because the equipment and software-related costs are not prohibitive. The method might also be appropriate during conservation of other types of artworks (e.g. mosaics, paintings, carpets, tapestries).

It is worth mentioning that GIS technology was already taken into account and applied for very similar purposes in cultural heritage information systems. In this respect, an exquisite and complex example is the work of the team conducted by Professor Carlo Monti in St Mark's Basilica in Venice, Italy (Monti *et al.*, 1998).

Unlike traditional methods, the proposed method does not imply any special drawing ability on the conservator's part. Thus, for the recording of the thematic component – which corresponds to the deteriorated areas or to the specific conservation interventions – a short training period of 2-3 days is required.

The saving of the conservator's time is another important issue. We estimate that by applying the proposed method, the conservator's time spent on graphic documentation reduces from months to weeks.

By using the proposed method, symbol standardization may become an easier task, because a lot of symbol sets used in GIS applications can be used – without any further modification, for graphic documentation purposes. In any case, in our opinion, symbol standardization in graphic documentation should ensure flexibility. Therefore, symbol standardization for classes of recorded phenomena might be sufficient.

We emphasize that the use of GIS technology in mural painting graphic documentation does not exclude the use of other information technologies whenever appropriate (e.g. CAD, desktop publishing, RDBMS). Moreover, as GIS was designed to treat heterogeneous information, it naturally ensures easy integration and interoperability with other classes of software applications.

Nevertheless, it is up to the conservator to finally decide the adequacy of applying the method, taking into account the complexity of the mural painting conservation tasks. It is very important to note that the use of information technology in mural painting conservation represents nothing but a possible useful tool and should not induce considerable additional efforts.

By applying the proposed method, the graphic documentation becomes a spatial database, which can be naturally extended to the entire mural painting documentation. In this way, better cultural heritage information management is enabled.

The method has several advantages over the traditional ones. For example: the objective nature of the graphic basis, ease of updating and symbolizing, more accurate area and length measurements, unlimited overlay and display possibilities, ease of manipulation, ease of cross-links with other data, relatively simple 3-D simulations.

Possible drawbacks are those generally inherent for any operational implementation of a new information technology. Maybe the most important is generated by the difficulties in creating a dedicated infrastructure (personnel, equipment, software). This is true both for the conservation team level and for the cultural heritage institutional level. Furthermore, difficulties in integration with existing traditional documentation and archiving systems, difficulties in creating an appropriate system for training and education must also be mentioned.

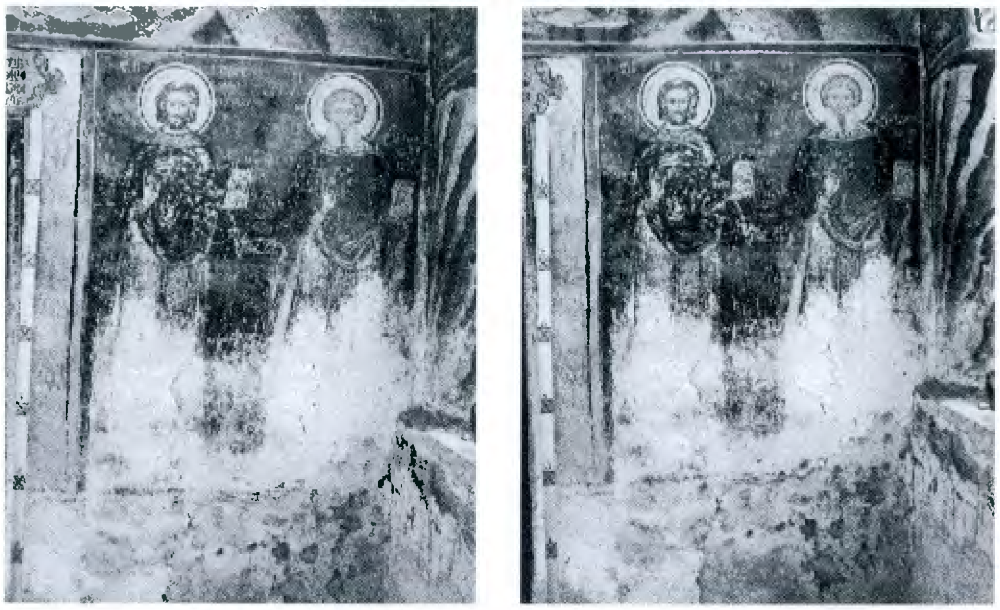

Figure 1. Scanned photograph (left) and the corresponding rectified image (right).

Figure 2. Thematic component (right) and the same overlaid onto the graphic reference basis (left).

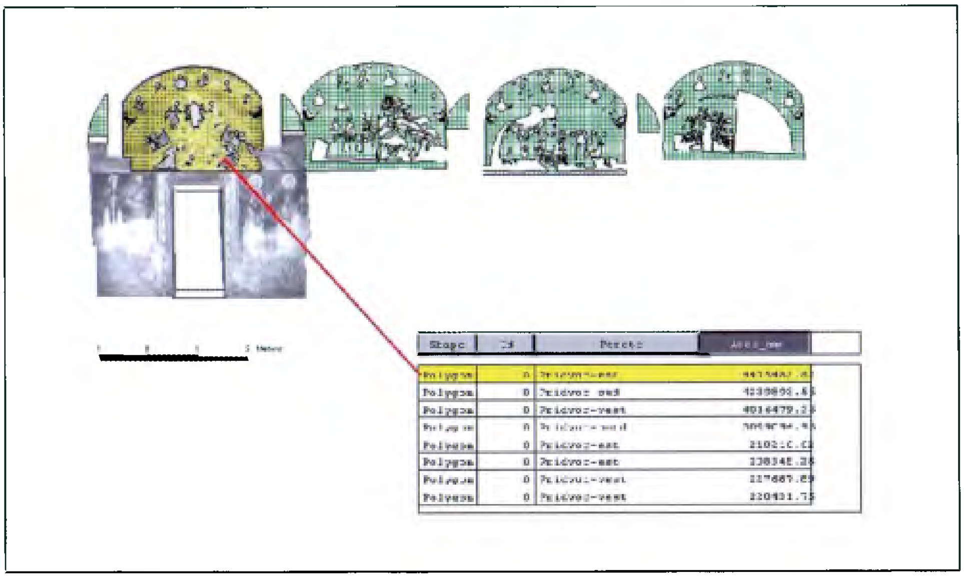

Figure 3. Descriptive tabular data attached to the thematic component; automated area computation.

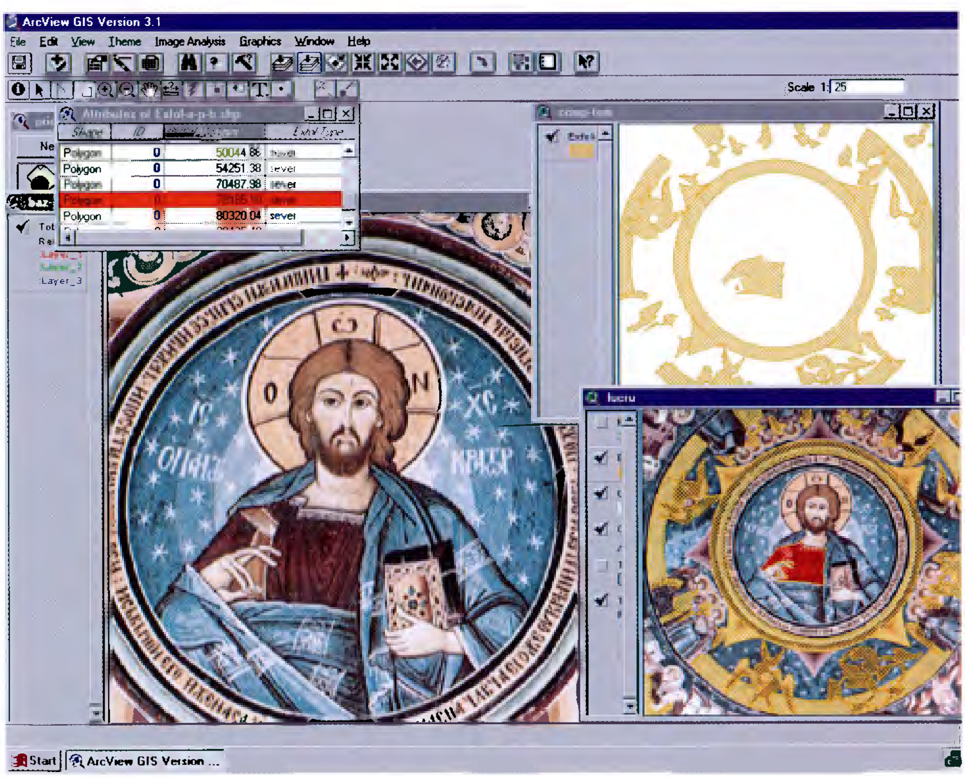

Figure 4. A screen capture illustrating the three components of the digital survey corresponding to the upper part of the exonartex vault: the graphic reference basis (lower-left), one of the thematic layers (upper-right), and its associated descriptive component (i.e. table) in upper-left. The result of overlaying the thematic component onto the graphic reference basis is shown in lower-right. As one can easily see, the 'red' row of the table corresponds to the 'red' polygon in the lower-right image.

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FOOTNOTES

1 **remote sensing:** acquiring information about an object without contacting it physically. Methods include aerial photography, radar, and satellite imagery.

2 **computer network:** computer data communications technology which connects computers at the same site (local area network – LAN) or remote sites (wide area network – WAN). Computers and terminals on a **LAN** can freely share data and peripheral devices, such as scanners, printers and plotters. LAN are composed of cabling and special data communications hardware and software. **WANs** are composed of special data communications hardware and software and usually operate across public or dedicated telephone networks.

3 **coordinate system:** a reference system used to measure horizontal and vertical distances on a map or image. A common coordinate system is used to spatially overlay graphic data for the same area.

4 **accuracy:** the closeness of results of observations, computations or estimates to the true values or the values accepted as being true. ***Accuracy*** relates to the exactness of the result, and is distinguished from ***precision,*** which relates to the exactness of the operation by which the result is obtained. In the context of mural painting graphic documentation, high positional accuracy means 1-10 mm.

5 **image rectification:** the process by which an image is converted from image coordinates to real-world coordinates.

6 **desktop publishing (DTP):** computerized publishing system based on desktop computers.

7 **relational data base management systems (RDBMS):** a method of structuring data as collections of tables that are logically associated to each other by shared attributes. Any data element can be found in a table by knowing the name of the table, the name of the column (attribute name) and the unique identifier of the row in the table (primary key).

8 **image enhancement:** the process of altering the appearance of an image for the purpose of extraction of additional information.

9 **contrast stretching:** the process of increasing the contrast of images by digital or optical processing.

10 **classification:** the process of assigning individual pixels to categories on the basis of pixel value characteristics.

11 **attribute:** an attribute is usually represented in the computer as a column in a table.

12 **close relationship:** using GIS terminology, this paragraph informally describes the basics of the "geo-relational" model.

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MANUAL OR DIGITAL GRAPHIC DOCUMENTATION: DEVELOPMENT OF STANDARDS

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ABSTRACT

In the Niedersächsisches Landesamt für Denkmalpflege (NLD), documentation of conservation investigations is often effected using manual mapping. Using a standardized system, the graphic representation of phenomena is based on twelve predefined keys. In addition, standard hardware and software are used by a documentation specialist for both analysis of data and presentation and storage of results.

Practical experience since the beginning of the 1990s shows that the use of Computer-Aided Design (CAD) is one of the best ways to create basic data files with long-term compatibility. Combining CAD with image data links to text information, and ultimately to databases, can be a first step toward a more efficient information system for conservation interventions.

KEYWORDS: *condition recording; conservation documentation; graphic documentation; standardized mapping system; orientation system; base map; overlays; direct recording; indirect recording; CAD; raster file; vector file.*

INTRODUCTION

The most frequently used visual documentation medium for conservation condition recording and analysis continues to be manual mapping, and this has been generally accepted. There is no longer discussion on the aims and objectives of using manual maps before and while working: overall view maps and detailed maps have become an essential part of standard conservation reports.

Even the 'new' issue of whether restoration should in general be documented manually or digitally using computerized techniques is largely academic. There are contrasting points of view on this: some think that documentation will fall behind if modern technology is not applied and that conservators will miss the boat with regard to up-to-date communication methods and analysis. Others see that using a computer for restoration documentation implies considerably more time and money to achieve results of good, or even merely acceptable, quality. Experience shows that it is more difficult to establish usable categories for phenomenon mapping and to select typical object-specific phenomena than it

is to choose tools to graphically represent them. It will be interesting to follow further developments in this field.
This article is intended as a first attempt to show various solutions to the graphic documentation dilemma, and to present field-tested techniques from a critical viewpoint.

THE NLD MANUAL MAPPING SYSTEM

Since the early 1990s, a standardized mapping system has been in use for condition recording in the restoration department of the *Niedersächsisches Landesamt für Denkmalpflege* (NLD) [Lower Saxonian State Conservation Office] (e.g. VDI, 1987; Eickelberg, Herppich and Zallmanzig, 1990). The goal was and is to achieve nation-wide standardization of representational symbology (symbols, line signatures, hatchings, tints, etc.). Since then, the set of standard sheets (Figures 4 and 4a) developed for this system have been used for manual mapping.

Figure 1. Materials for manual mapping. Base map and overlay are fixed congruently using a drawing board. The corners of the photographic base map are copied as reference marks on all overlays.

Preparation of a manual mapping campaign

In order to be successful and to obtain as much information as possible, careful planning is recommended before starting mapping *in situ*. It is often impossible to obtain missing material and supplies at short notice, once the project has started (Figure 1).

The subdivision of larger objects into sectors or areas, i.e. the creation of an orientation system, also provides a grid for the systematic production of photographic documentation. Thus, each overlapping photograph can automatically become a base map for manual recording (Figures 2 and 3).
The total cost of the operation largely depends on the mapping method, and some questions need to be answered at the outset:

- Is it really necessary to use coloured mapping methods? (Figure 5)
- Is it possible to achieve the same result by using monochrome mapping methods, or can coloured and B&W graphic techniques be mixed?
- How many copies of the documentation are expected to be needed, and how will this affect reproduction costs?

When using the NLD system, careful adherence to the following points should allow all documents to be complete and ready for archiving after mapping (Behrens and Klein, 1996).

NLD Mapping System – Recording Tools

It is important to order the material for the overlays (polyester transparencies for photocopying onto) in good time. In Germany there are delivery periods of up to three weeks. For calculating the number of overlays required, one transparency is usually required per photograph and category of mapping. If more than one person is participating in the campaign and will cover the same areas, it is necessary to multiply the number of overlays by the number of people involved .
Each person will require a minimum set of drawing tools, including a fine, hard black-lead pencil; eraser; pencil sharpener; A4 drawing board; and an appropriate selection of standard coloured pencils for the phenomena likely to be encountered. The use of Schwan *Stabilo* pencils is specified in the NLD mapping system, based on the RAL (German Institute for Quality Assurance and Labelling) colour palette. Pencils must be ordered separately, because a complete set of the selected colours is not available (Figure 1), and it is important to have the coloured pencils available in good time.

NLD Mapping System – Supporting Documents

The following preparations are necessary before starting work on site:

- Fix the photographic base maps onto the A4 drawing boards, ready for the superimposition of the transparent mapping overlay (Figures 4 and 4a).

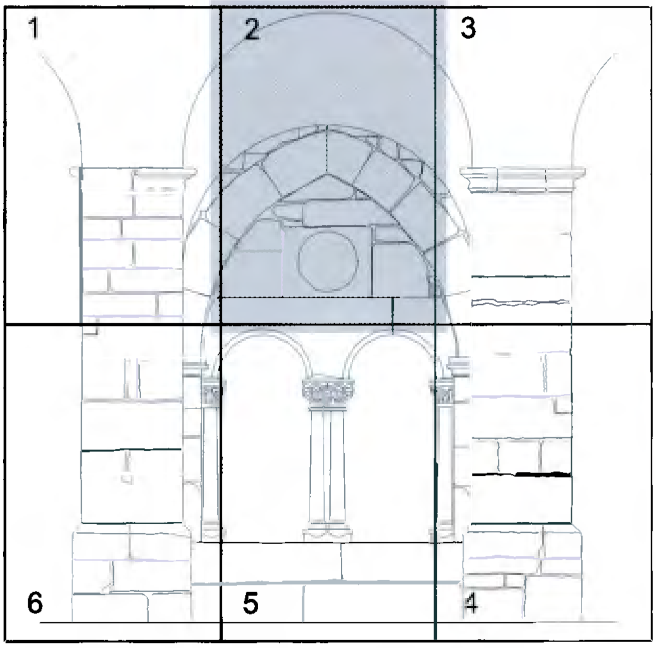

Figure 2. Example for a free orientation-system on a wall.
1 area = 1 photo = 1 overlay. To every area a code-number is assigned.

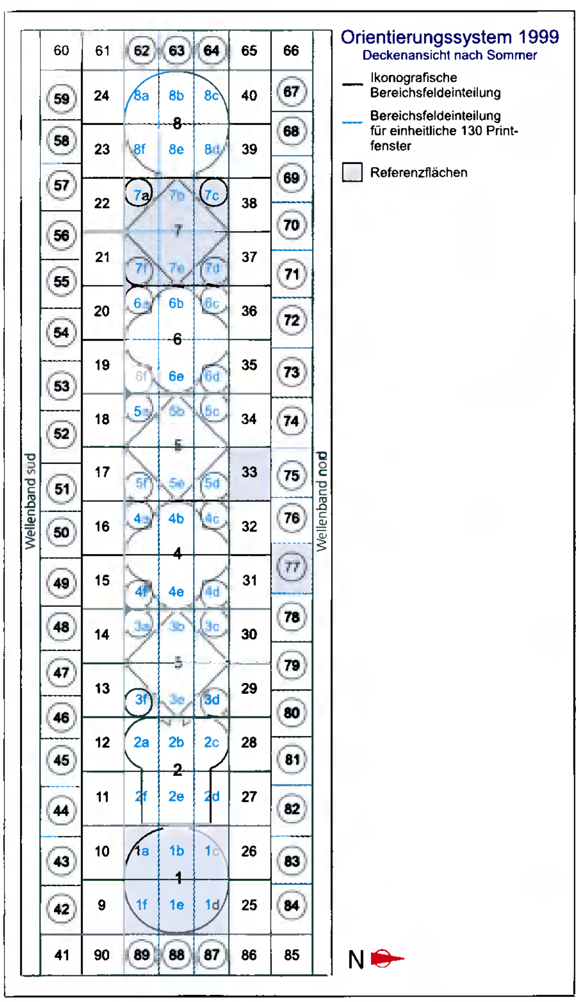

Figure 3. Germany, Protestant church of St Michael, Romanesque ceiling with 90 iconographic areas. Example of an exact orientation system.

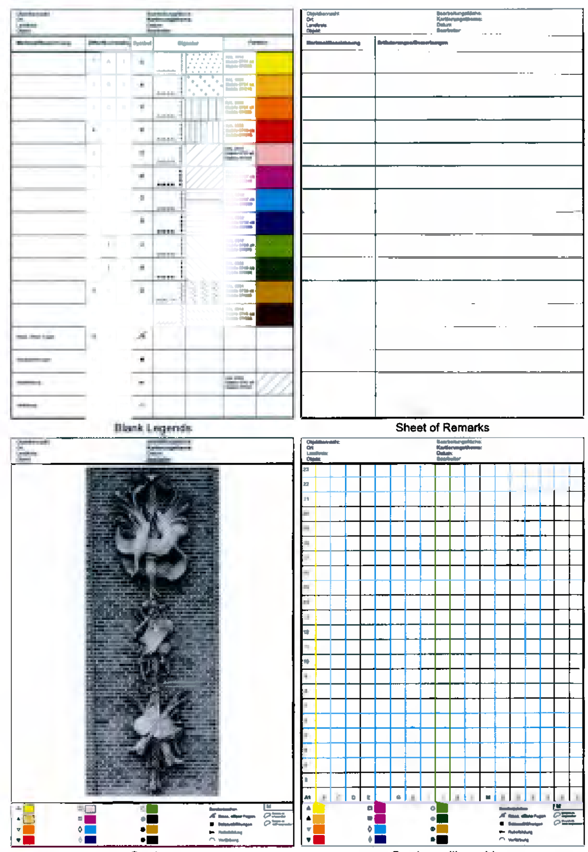

Figure 4. A-4 forms for manual and digital mapping according to VDI 3798, additional sheet 3.
These basic documents are available as CAD and graphics templates. They can be duplicated by printing or copying the documents.
Left upper figure: An example of a blank legend form constituting the 'table of contents' of one mapping category. In this case 12 legends with their respective graphic representation are possible.
Right upper figure: Sheet for remarks used for manual annotations of observations made during mapping.
This form relates to the blank legend.
Left lower figure: the mapping form (overlay).
For manual mapping only monochrome copies are made, including black&white symbols or hatchings. The digital version (here represented) is using colour; if necessary the base map can be retrieved together with the overlay for quantitative mapping.

Phenomenon/Name	Number/Letter			Symbol	Signature	Color	
New mechanical defect	4	D	IV	∇		RAL 3002 Stabilo 8748 old Stabilo 87/315	

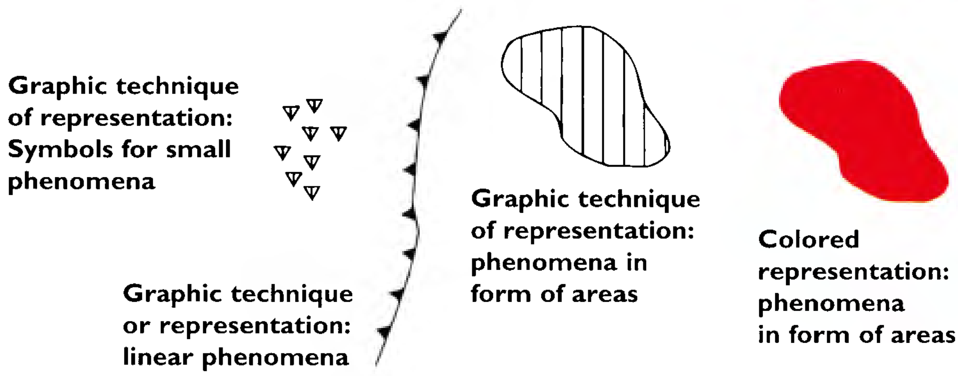

Figure 4a. Detail of the blank legend (row four). The definition of phenomena pertaining to one category is done horizontally. During manual mapping on one single mapping form (overlay), both monochrome and coloured representation tools can be used (see also fig.5,6,15). Although different representation tools are used to record the same phenomenon, the assignment to a phenomenon (in this case new losses) will always be possible by referring to the legend.

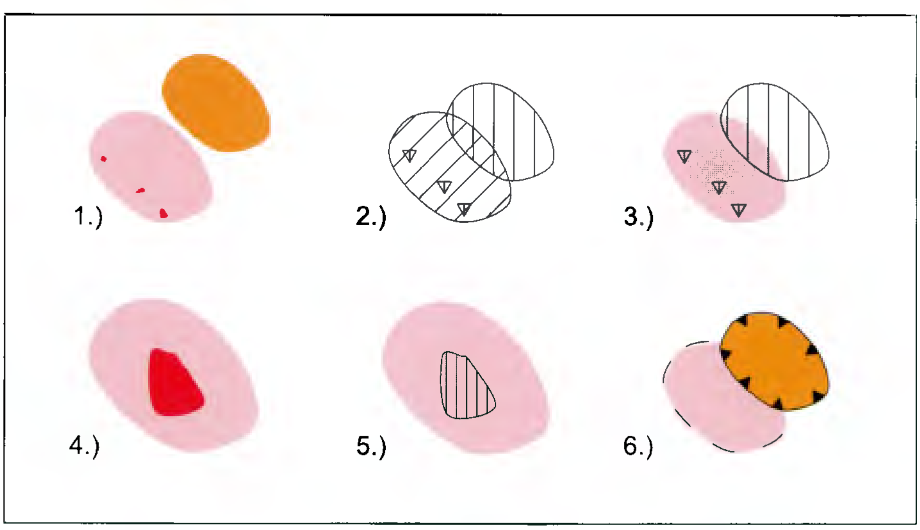

Figure 5.

Figure 6. Germany, Clemenswerth castle, stone sculpture on the palatial building. Photographic base map with mapped phenomena on superimposed mapping sheet (overlay).

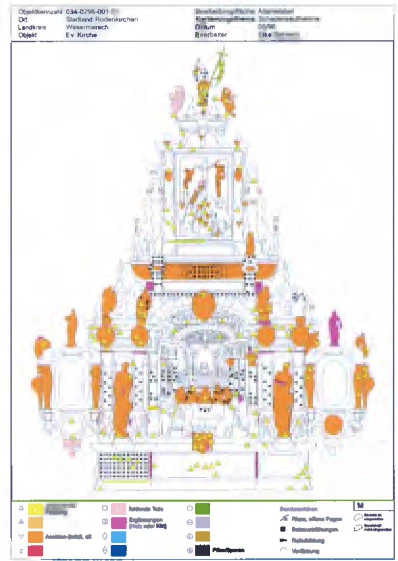

Figure 7. Germany, Stadland-Rodenkirchen, Protestant church, altarpiece. This graphic record gives a general view of all mapped phenomena relating to the condition of the altar. For a more detailed analysis, it is necessary to study the original documents.

Figure 8. Germany, Protestant church of St Michael, Romanesque ceiling. The *in situ* mapping of damage.

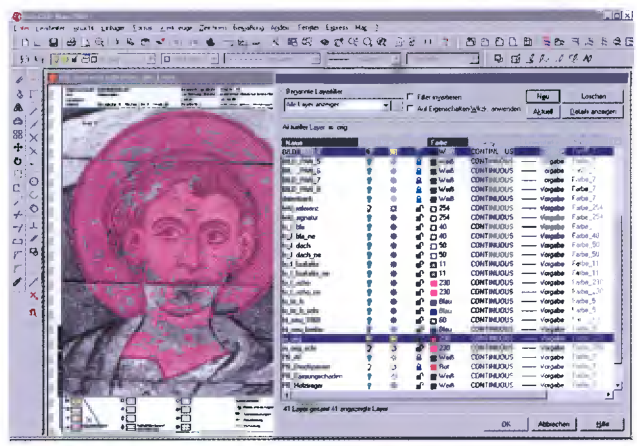

Figure 9. Germany, Protestant church of St Michael, Romanesque ceiling. CAD-mapping on the base of a rectified black&white image. The layer concept was developed on the basis of the mapping system according to VDI 3798, additional sheet 3.

Figure 10. Germany, Protestant church of St Michael, Romanesque ceiling. CAD-mapping in area 7 *(Mary)* on the base of a rectified colour image.

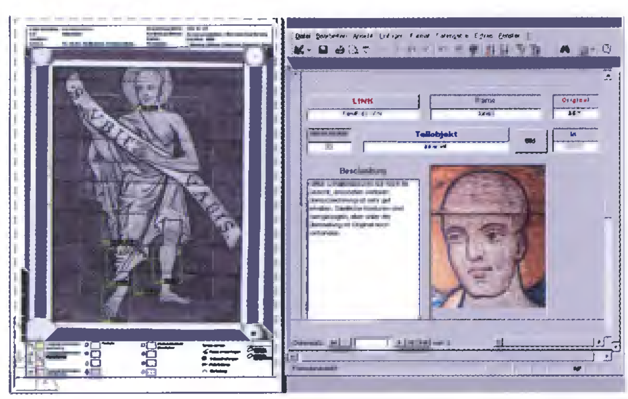

Figure 11. Germany, Protestant church of St Michael, Romanesque ceiling. Links between database and CAD file in area 33 *(Jonas)*.

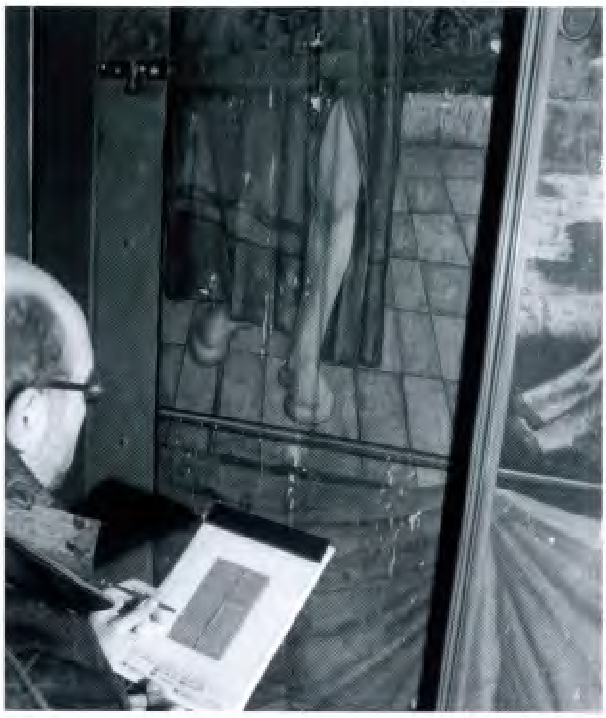

Figure 12. Germany, Goslar, city hall, *Huldigungssaal*. Direct recording of conditions of a Gothic panel painting.

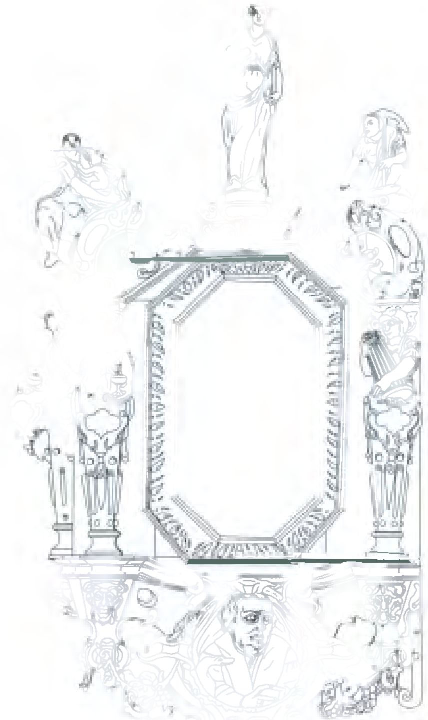

Figure 13. Germany, Stadland-Rodenkirchen, Protestant church, altarpiece, left stringboard. The quality of this line drawing produced via CAD meets the standards of a manually produced drawing.

- On the basis of preliminary information from the site, define the mapping categories and establish a so-called 'blank' legend; it is also useful to test the chosen colouring and graphic techniques prior to going on site (Figures 5 and 6).
- Copy the complete set of mapping forms (at least one for each category) onto polyester transparencies, using a monochrome photocopier (Figure 2).
- Copy the blank legend and the remarks sheet onto paper using a monochrome photocopier (the complete set is required, one for each category) (Figure 4).
- Pre-sort and pack all documentation materials (e.g. in cardboard boxes or in ring binders) so that all materials are handy *in situ.*

How to carry out mapping

The first step is to check rules and procedures previously developed, both on site and in the office. If several people are to work together, it is better to make a trial map. It is important that all agree on the definition of and graphic representation for each phenomenon to be recorded. If definitions remain unclear or are interpreted differently within the team, the maps will be arbitrary and not comparable, making future evaluation and analysis difficult and probably inaccurate.

Using the photographic base map as a reference, phenomena are directly recorded onto the transparent polyester overlay, onto which the mapping form was copied (Figure 12). Usually, the third standard form is used (Figures 4 and 6), which includes a legend and a heading for clear identification. How many overlays per category of mapping are used is a decision that lies with the operator. Contrary to other types of clear overlays (acetates, etc.), the matt finish of polyester transparencies designed for technical drafting allows the use of various drawing utensils, including coloured pencils, drafting lead holders, etc. Moreover, polyester transparencies are very durable, dimensionally stable and can be archived for a long time.

In order to save space, single pre-printed overlays (i.e. mapping forms) contain only an abbreviated version of the blank legend, which gives a complete list of all the representation tools such as symbols, hatching and tints (Figures 4 and 4a). The 12 legend boxes at the bottom of each mapping form are grouped in the same sequence as the blank legend.

Conclusions regarding manual mapping

Systematically structured manual mapping provides visual information on the current condition of an object. It is the first non-destructive examination method that provides a representation of the object, thus making a considerable contribution to condition assessment.

The low cost of form sheet reproduction is significant. Forms can be used directly for hand-written notes and for the presentation of mapping results (Figures 6 to 8). In general, people who have their first experience with graphic documentation through manual mapping are those best qualified for future digital mapping. The most important aspect in data collection should be to reduce information to its essential elements.

After years of testing, the base as a part of the NLD mapping system was published in January 1999 as an addition to the VDI Norm 3798, Sheet 3 for graphic documentation in condition recording (VDI, 1999).

DIGITAL MAPPING

In the beginning was the line drawing, and it was good. The first conservation maps were carried out using normal blueprints of the building plans produced by architects. In the field of visual documentation in the NLD restoration department, these documents and others were prepared to provide support for all phases of a project, or modified, especially with regard to architecture, to visualize hypothetical reconstructions or re-integrations. The first encounter with Personal Computers (PCs) at the beginning of the 1990s immediately made people want to try to make drawings using this auxiliary medium, in order to rationalize work procedures and to avoid having to start again from the beginning when modifications had to be included (Figure 13).

First steps – mapping using CAD

In NLD, the first digital mapping exercise to be carried out with CAD used AutoCAD. The project was the 7th bay of the cloister in St Michael's Church, Hildesheim, Germany (Figure 15), and had good results, but was also disappointing. Computer programs must be learnt, mastered and constantly used to maintain familiarity. At the same time, data entry takes as long as drawing by hand, and technical constraints appear due to PC software and hardware limitations.

Why use CAD? It was developed as a program for architects, engineers and designers for drawing presentations in two and three dimensions according to coordinates. However, using a CAD program allows the use of the graphic representational symbols of the NLD mapping system (points, lines, hatching) available as drawing tools, with the exception of tinting (Beck & Behrens, 1993). The integrated layer management is useful for systematic and separate data filing. Inputs can be made via digitizer, keyboard or mouse, and hardcopy outputs up to A0 size can be made using printers or plotters (Figure 14).

Unfortunately, the use of hatching results in very large data files, and large formats create problems with regard to input and output (Figure 14). For this reason, the amount of data should be minimized right from the beginning by concentrating on essentials.

Consequences for daily work

Within the *Wandmalereischäden* [wall-painting damage] Research Project financed by the German Federal Ministry for Research and Technology (BMFT) (Anon., 1994) and organized in co-operation with the NLD, forms reduced to A4 size were developed for manual and computer-aided recording (Beck & Behrens, 1993).

For the first time, these forms were produced using CAD, and then graphics software (Figure 4). Then as now, in digital mapping using a PC, the subdivision of objects into referenced areas allows for faster data processing. Manual and digital recording were therefore developed in parallel, with the aim of producing a standardized approach.

Figure 14. CAD workstation with A1 digitizer for introducing large maps.

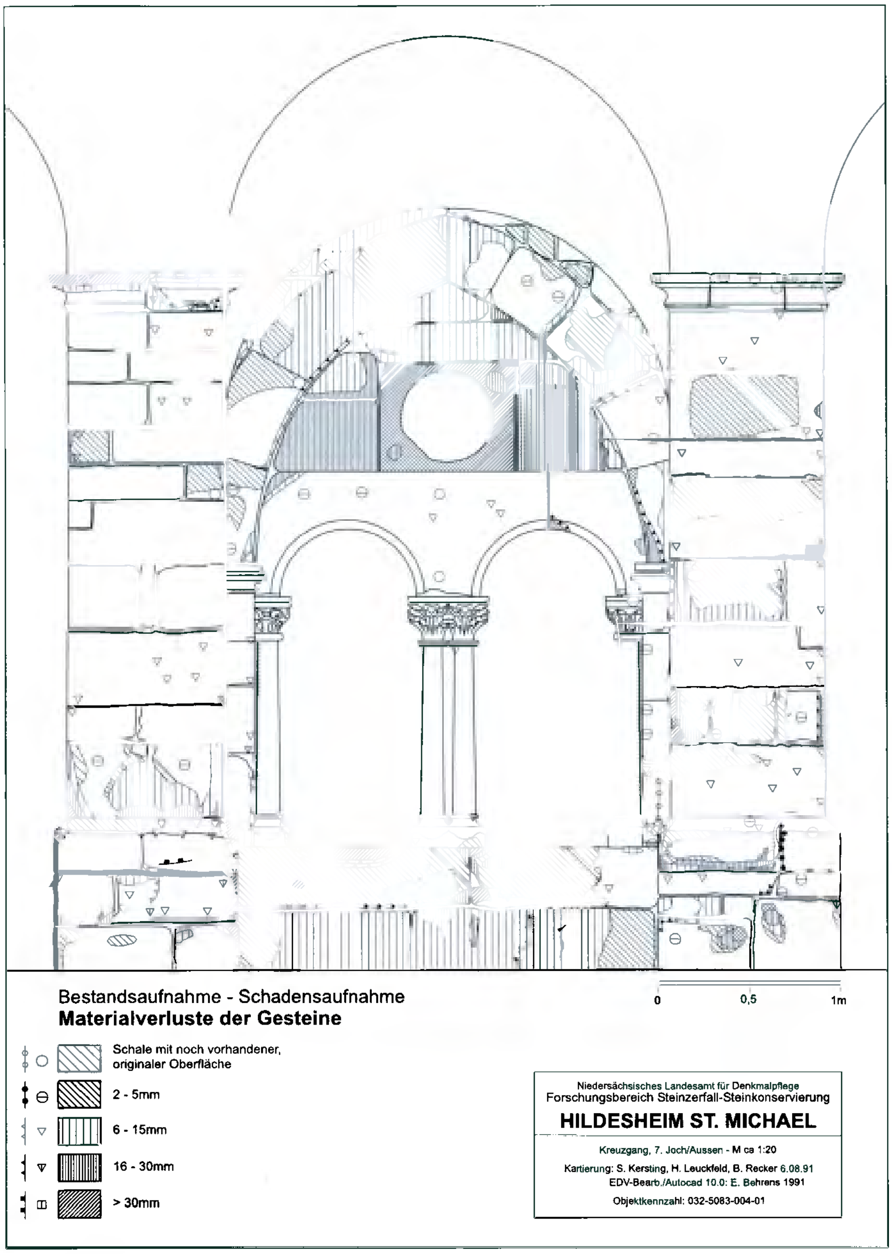

Figure 15. Germany, Hildesheim, Protestant church of St Michael, cloister, 7th bay east wall outside. CAD mapping of lost stone material carried out in 1991 according to the system of the Working Group 'Condition recording' *(Bestandsaufnahme)* of the former *BMFT* Research Project - Deterioration and Conservation of Natural Stone *(Steinzerfall-Steinkonservierung)* - relevant VDI 3798, additional sheet 3.

A limitation of computer-aided systems is the fact that during work on an object, it is impossible to enter all existing documents into the PC because it would require too much effort. For example, the large amount of time required to scan, process and print photographs (even in smaller formats, such as A4) should not be underestimated. It depends on resolution and file format of the image data and can be easily calculated. As a consequence, computer-aided documentation is currently restricted to selected cultural objects (mural painting, stone conservation, etc.) (Behrens & Stadlbauer, 1998), although computer graphics increasingly are being applied for presentation purposes and for the visualization of summary results.

The introduction of sophisticated computer-based documentation has required the creation of a new – almost independent – area of responsibility, that of the documentation specialist, with a new type of expertise and use of a computer workstation dedicated exclusively to conservation documentation. Due to incredibly fast development in PC technology, from the MS-DOS operating system underlying Windows 3.11 to Windows 95/98, and Windows NT 4.0, documentation experts require constant updating of skills, and newcomers have to invest a lot of time in acquiring the necessary specialized skills. A thorough knowledge of computer technology, documentation techniques and heritage conservation is indispensable. This is why at present only a few freelance restoration companies in Germany produce complete documentation using PCs. Normally, only word processing and spreadsheets functions are used. This will perhaps change in the future!

Basic conditions and preparations
At present, it is impossible to fulfil the dream of having 'easy-to-handle' PC-based mapping software for restorers off-the-shelf because a combination of different program components is used in visual or graphic documentation. The most important programs are CAD, graphic, scanning, image processing, word processing, spreadsheet and desktop publishing.
It is important to observe the following points:

- Available financial resources constrain equipment specification.
- In image and graphic data applications, the requirements for hardware and software are higher than for simpler office applications.
- Scanners and digitizers are necessary for input; colour printers and special photographic paper (very expensive) are needed for high-quality output in hard copy.
- Larger data files require larger memory resources and powerful back-up systems.
- Data exchange with outside partners requires compatibility, best achievable through use of standard software.
- Data management includes constantly updating software and old files for compatibility with new program versions (this can sometimes result in loss of format).
- Preparation of templates (e.g. mapping forms) as so-called prototype files (Figure 4).
- Development of orientation systems and signatures for data management (Figures 3 and 11).
- Production of base maps, as either drawing files or scanned images, that can be imported to complete style sheets (Figure 4).

How to carry out digital mapping
The preliminary considerations in conceptualizing a digital mapping operation are identical with those needed for manual mapping, namely compiling and testing of categories and their legends. In order to convert the NLD mapping system representation techniques into digital format, a program with the following software options is required:

- Image data filing with open scale.
- Text information filing with formatting options.
- Drawing tools for entering points, lines, geometrical forms, symbols, hatching and coloured areas (opaque and transparent) with all formatting options.
- Layers for phenomenon-oriented filing.
- Connection to databases for future statistical evaluation.
- Connection to Geographical Information Systems (GIS).

Some of these components are a standard part of graphics programs such as Micrograf Designer, Macromedia Freehand or CorelDraw, while some of them are found in image processing programs, such as Adobe PhotoShop and CAD programs (e.g. AutoCAD or Microstation). Only the most popular programs are mentioned here.
Of course, the best method is to carry out mapping directly on the PC. In this case, monochrome (usually) image data are used as base maps (Figure 9). These can be zoomed-in to make details visible on the screen. The contours of area phenomena are marked by a closed outline and the enclosed area is coloured or hatched. For point phenomena, a set of symbols that can be copied are used. Mapping is done layer by layer, according to the categories. (Figures 2, 9 and 10). Printouts are used for visual control of the work and for archiving.

Combination of manual and digital mapping
If the mapping is done directly using a PC, manually produced documents can be integrated subsequently without problems. The scanning of manually produced overlays, followed perhaps by vectorization of the produced bitmap data, could be con-

sidered a good alternative to direct recording.

It is recommended that monochrome representation tools be used. People who know what coloured-original overlays look like can imagine what it would mean to scan them. Depending on the preliminary settings, the scan is often similar to a coloured photocopy. If, in the heat of the moment, the conservator has applied colours irregularly or too thinly, scanners as well as colour photocopiers interpret these as patterns and produce inaccuracies, i.e. parts are missing. A scanned image can at best have the same standard of quality as its original, and so it often becomes necessary to edit the images afterwards by retouching or correcting colours. This costs time and money.

Here are some ideas for economizing efforts:

- Scan the mapping photographs in reproduction size with a 200 to 300 dpi resolution and save them in .TIF, .EPS or .JPG format (the most used formats for image data).
- Make provisional original maps on clear overlays, using only B&W graphic signs with drafting leadholders or fine-line permanent markers (Figure 5, monochrome mapping). Such maps are temporary products and not appropriate for archiving.
- Carry out a monochrome (B&W only) scan of these overlays – not greyscale – as interpretation of two colours results in a smaller data file size.
- Depending on the program, import, save and redraw the image data, because several image files superimposed in one file obscure each other. In AutoCAD, such scanned files are imported as bitmap (.BMP) files, formatted transparently and treated like a line drawing by changing the colours. It is possible to import and superimpose several sets of image data (Behrens, 1998).
- It is true that PhotoShop allows transparent layers to be produced, and thus several image files to be connected, but, unfortunately, as a pure bitmap program it has no vector-oriented drawing tools and every new layer produces more data. The size of one PhotoShop file can expand rapidly, and this is a great disadvantage.

Before starting mapping, it is really important to know whether the manual maps are to be processed digitally afterwards (indirect recording). What is described here is just one methodology. A professional PC user could probably conceive of other methods, such as vectorizing.

Conclusion on digital mapping

A series of trials with different standard software suites operating under Microsoft Windows has brought us directly back to AutoCAD, especially as since Version 14 one can include image data. Practical experience with CAD data has shown good results with regard to long-term compatibility of document files without data losses because CAD programs are for professional applications where files must be accessible for long periods, even though software versions change (Behrens, 1998).

Using CAD programs is a first, solid step for those who want to work with the PC in a forward-looking way today. In the future, a possible procedure when using GIS software would be to link image data (raster files) and CAD data (vectorized files) with database information systems (Figure 11). Nevertheless, it is still perfectly okay for people to use, for example, standard, medium-priced graphics programs because these produce excellent documents for presentation.

Using standard programs on a PC improves people's skills and is good practice for coping with potential problems, such as program bugs, driver problems and data losses that unfortunately cannot be avoided. Someone who wishes to concentrate on digital documentation must make this decision on their own.

OUTLOOK

Digital methods have not yet reached maturity. It is necessary to test and critically evaluate them on the basis of innovative research projects. Someone who is acquainted with environmental conditions on worksites will probably be negative toward mapping being carried out on the scaffolding straight into a PC. It is obvious that heat, cold, dust and vibration have undesirable effects on sensitive devices such as computers, monitors and printers. The development of complex information systems (Beck, Temme & Rademacher, 1996) requires a team of experts in different fields, and considerable financial resources. The publication of results on the Internet would be a further step into the future.

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15
A USER-FRIENDLY APPROACH (... MORE ABOUT STANDARDS AND CUSTOMIZED MENUS IN DIGITAL RECORDING OF CONDITION)

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Qualcuno mi ha detto che certo le mie poesie non cambieranno il mondo. Io rispondo che certo sì le mie poesie non cambieranno il mondo	Someone told me that my poems will certainly not change the world. I reply that my poems will certainly not change the world.

Patrizia Cavalli, 1974

ABSTRACT

Since 1992, the Istituto Centrale per il Restauro (ICR) has been working on a project aimed at simplifying the use of computer-aided documentation tools in thematic mapping in order to allow direct, *in situ* data entry. It is now possible to review final results and to propose guidelines for standard documentation.
A well-customized system facilitates data entry and enables conservators, unfamiliar with the use of AutoCAD™, to quickly enter condition data. It also allows the development of technical skills in the conservator, thus breaking the graphics experts' monopoly and promoting greater interdisciplinary collaboration.
This paper does not provide conclusions - rather it puts forward a series of discussion points, namely:
- the pros and cons of using Computer-Aided Design (CAD) methods and techniques beyond simple drafting;
- a critical understanding of failures and experiences with a specific form for each experience; and
- layer naming hierarchical systems and international and Italian guidelines and standards for the recording, visualization and archiving phases in digital documentation processes.

KEYWORDS: *computer; computer-aided design; condition report; documentation; documentation technique; education; mapping; mural painting.*

INTRODUCTION

Computer-assisted drafting techniques have rapidly become a part of conservation and are now set to become the standard method for producing information about conservation activities. The Istituto Centrale per il Restauro (ICR) has set in motion a series of experimental studies in this area, both for documentation of individual objects (mural paintings, sculpture, architectural surfaces) and for regional studies. This experience has brought to light several crucial problems concerning the handling of information in digital form: accurate definition of symbols for the various forms of deterioration; methods used for the acquisition of scale drawings; structuring of the documentation; and standardization of the symbols (coloured fields and patterns) for the representation of the various types of historical and conservation information. (Cordaro, 1999).

Figure 1.

DOCUMENTATION AS A SCIENTIFIC TOOL

The objective characterization and description of an object through the mapping of its decay, or rather through the recognition of the material and its pathology, is one of the research themes that has occupied ICR experts over the last few years. Beginning with the first statements of Urbani (1984), this has contributed to the building up of a working practice for the surveying, recognition and classification of the object to be conserved: metrology, iconographic representation, material decay symptomatology and the techniques of construction are some of these measurable qualities and quantities.

The role that technical-scientific research plays in the field of conservation "corresponds to the identification of the instruments necessary for a more exact characterization of the monument," which amongst other things may be:

> "a more exhaustive technical documentation of the object, that includes not only the written report and the photographic studies but also graphs and the integration of irregularities that might not necessarily be visible to the naked eye. The first time that the use of graphics was really applied to the field of conservation was between 1954 and 1955 in the drawings (Figure 1) done during the work on the panel painting of the Madonna della Clemenza [in the church of Santa Maria in Trastevere, Rome, Italy] (Bertelli, 1964). It began to be applied, as we know it, in 1973 at ICR when the assistant to the paintings on wood course, M. Nimmo, covered the painted surface of the objects with architect's tracing paper to record the technique of execution and the state of conservation" (Rissotto, 2000).

In the course of time, acetate sheets replaced tracing paper. These acetates were placed over the photographs, thus presaging the concept of overlays as used today in computer-aided graphic documentation.

A gradual transfer of the documentation onus from the conservators to the architects has meant that there is now much less margin for error in the surveying phases. In fact, since the end of the 1970s, conservators have tended to provide only the data, while architects were responsible for producing base maps and elaborating the final presentation.

Today, the tendency for the entire graphic documentation process to revert to the hands of the conservator (possibly assisted by a documentation specialist) – as defined in various professional Codes of Ethics – has in effect redefined documentation as an integral part of the conservation operation. As such, the documentation responsibility presupposes a familiarity with whatever instruments and techniques (including innovative technologies) are at the disposal of the operator without in any way compromising the precision and verisimilitude of the final result.

USER-FRIENDLY APPROACH

At ICR, the application of computerized documentation techniques began in the mid-1980s. The research aimed to link the three-dimensional information produced by stereo-photogrammetric systems with the graphic conservation documentation produced using CAD software (Aramini and Capogrossi, 1988).

Since 1992, the author has been in charge of an ICR project that aims to simplify the use of CAD tools in mural painting documentation, using a customized menu. At the same time, the ICR documentation department also adopted different graphic software for the documentation of institutional projects. The interest in and use of these innovative systems of digital documentation have been diffused successfully amongst the conservation students at the Istituto. ICR and the Opificio delle Pietre Dure (OPD) are the two Italian state institutions offering a degree of '*restauratore*'. In 1997, a new organizational structure was developed covering aims, administrative structure and theoretical disciplines. The new teaching programmes include digital documentation at both institutions.

However, the principal goal of the project has not yet been achieved, that of reaching a situation in which the conservator could digitally report – using customized software and input interfaces – all the data definitively and directly on site, structured by categories and conforming to the NorMaL 1/88 recommendations (CNR-ICR, 1988) (Figure 2). The study group known as Normativa Materiali Lapidei (NorMaL) was formed in 1977, on the joint initiative of ICR and the Consiglio Nazionale delle Ricerche (CNR), with the objective of establishing standard methods for the study of the alteration of natural stone, stuccoes and mortars, and for control of the efficacy of the conservation treatments used on cultural objects. Of the various committees, two are of particular interest in the present context: *Drawing methods* and *Documentation methods.*

The project involved not so much the building of all-new software, but rather the testing and adaptation of market-oriented standards. The technical drawing standard is *de facto* AutoCAD (AutoDesk, Inc.) for both diffusion and standard definition.

Digital systems of documentation (AutoCAD based) were tested successfully in a number of research contexts: didactic worksites; diploma theses; and in collaboration with other public institutions and private conservators (Table 1)

After eight years of development it is now timely to publish project results and to share experiences.

The general objectives of the research were:

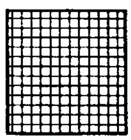
- study the structuring (i.e. hierarchy and relationships) of different types of data;
- evaluate analogue and digital documentation standards; and
- develop and test computer applications in conservation of cultural heritage.

The basic hypothesis is the necessity for the construction of shared models. These models should respect and integrate purpose, structures, processes and people of various professions, by using a small amount of technology, able to link information through Geographical Information Systems (GIS) (Box, 1999) with a simplified interface. If we wished to coin an acronym, it could be SILIS, standing for Simplified Interface Local Information System.

The principal characteristics of such a recording system must be economy, simplicity and absolute transparency for the user. This is what is meant by a user-friendly approach.

NORMAL	DOC. N° 1/88	APP. N°	ALL. N°	EDIZ. N° 2	Pag. n° 2/36

Alterazione cromatica. Alterazione che si manifesta attraverso la variazione di uno o più parametri che definiscono il colore: tinta *(hue)*, chiarezza *(value)*, saturazione *(chroma)*. Può manifestarsi con morfologie diverse a seconda delle condizioni e può riferirsi a zone ampie o localizzate.



Calcare (Nero di Bergamo)

Calcare (Alberese)

Figure 2. A page of the NORMAL 1/88 recommendations.

Figure 3, 4. Rome, Tempio Rettangolare at the Forum Boarium, *Gioacchino tra i pastori*, mural painting. A B&W photo (A. Munoz, 1925) used as base map and the Thematic Map for Techniques of Execution. From the thesis of Eliana Billi (photo and drawing by courtesy of E.B.).

	Work Site or Research Project	Data Source	Base Map	Documentati on structure	Digital mapping	Commitment	Purpose	Software Customizer	Data recording in situ	Digital recording	People involved in project
1	AM – Auditorium Mecenate	Digital Photo	Outline on digital photo	Adapted (La-SC2)	Site & Studio	ICR	Thesis	DCS:	Conservator		2
2	AW – Angkor Wat	Manual recording	Scanning Manual drawing	New	Site & Studio	Univ. Koln	Condition Recording	DCS + Conservator	Conservator		> 10
3	BS – Bet She'an	Digital Photo	Other: Digital orthophoto	New	Site	GCI/IAA	Test	DCS	Conservator & Doc. Specialist		2
4	CS – Cappella Scrovegni	Manual recording	Scanning Manual drawing	New	Site & Studio	ICR	Publication	DCS	Conservator	Doc. Specialist	2
5	CL – Casa Livia	Digital Photo	Outline on digital photo	Adapted (La-SC2)	Site & Studio	ICR	Thesis	DCS	Conservator	Conservator	2
6	ICCROM – Demo version	Manual recording	Scanning Manual drawing	New	Site	ICCROM	Demo	DCS	Conservator	Conservator	
7	LA – Los Angeles	Digital orthophoto	Other: Digital orthophoto	New	Site	GCI	Condition Recording	DCS	Conservator		4
8	MPC – MPC Worksite	Manual recording	Scanning Manual drawing	Adapted (ICCROM)	Site & Studio	ICCROM	Condition Recording	DCS	Conservator	Conservator	> 10
9	PL – Palazzo Labia	Manual recording	Scanning Manual drawing	Adapted (La)	Site & Studio	Sopr.VE	Condition Recording	DCS	Conservator	Other	2
10	SC1 – Worksite 1996	Manual recording	Scanning Manual drawing	New	Site	ICR	Condition Recording	DCS	Conservator		6
11	SC2 – Worksite 1997	Manual recording	Scanning Manual drawing	Adapted (SC1)	Site	ICR	Condition Recording	DCS	Conservator		> 10
12	SCB – San Clemente	Digital Photo	Outline on digital photo	Adapted (La-SC2)	Site	ICR	Condition Recording	DCS	Conservator	Conservator	6
13	SMM – S. Maria Maggiore	Manual recording	Other: Photo-gram., Scanner	New	Site & Studio	Vatican (GCI)	PreProject	DCS + Conservator	Conservator	Conservator	> 10
14	TR – Tempio Rotondo	Manual recording	Scanning Manual drawing	Adapted (La-SC2)	Site & Studio	ICR	Thesis	DCS	Conservator	Conservator	1

Table 1. Summary of the worksites where the customization structure was adopted.

TRIALS

First attempts are very rarely encouraging. The project began with the production of a digitized thematic map for the 1992 Condition Report of the Anagni Crypt frescoes, prepared by Art Historian S. Bianchi and Conservation Specialist F. Capanna. Neither the plots nor the results of that work were ever published, which implies that at that time there was very little interest in the concept of this project.

An all-new version of the customization was developed by an ICCROM/ICR research group for graphic documentation for conservation. This group was active in the early 1990s, with the goal – unfortunately never achieved – of producing a publication on graphic documentation in conservation. Coordinated by E. Giorgi for ICCROM, this publication only ever reached the draft stage, but included a series of contributions on the subject of graphic documentation written by various specialists from ICR, from ICCROM and from the Engineering Faculty of the University of Rome. A primary reason for the publication's never being printed was that, owing to the rapid development of computer technology, many aspects seemed to be already out-dated when the draft was nearing finalization.

One of the objectives pursued in a sub-project led by Buzzanca and Giorgi was to develop a standardized operational methodology for graphic documentation on worksites that would permit the registration and organization of data using information technology (Buzzanca and Giorgi, 1995). The publication also would have included a series of examples of work carried out by ICCROM and ICR, with the direct participation of G. Buzzanca and E. Giorgi. There was a lengthy section that was dedicated to the critical analysis of a series of experiences in the field of computer-assisted documentation. It would have included free distribution, in an appendix, of the *Information System for Collecting Historical and Conservation Data* that was to have included all the customization tools for historical-conservation data entry. The customization exercise, first carried out on AutoCAD release 12, was useful because it brought to light the various problems posed by the transfer of graphic data from manual to digital format.

A further experience was the computerized recording system, with simplified procedures, developed for the documentation of a complex cycle of frescoes, namely those by Giotto at the Scrovegni Chapel in Padua. In this case, the work – initiated by operators of the ICR documentation department – was carried through by private conservators who were graduates from ICR and specialized in documentation techniques (Orrù, 1995). Their task was take graphic documentation that was already available on paper and translate it into digital format. The same private con-

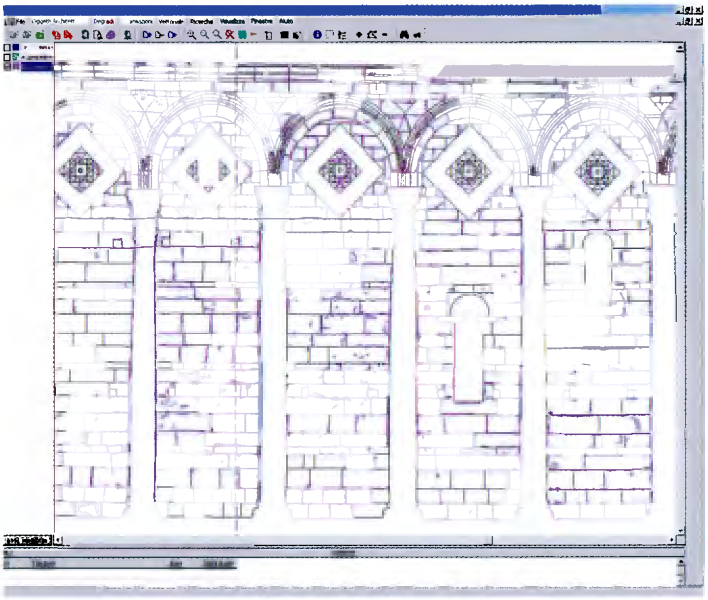


Figure 5. A thematic map from the Leaning Tower Project (drawing by courtesy of G. Capponi and U. Parrini).

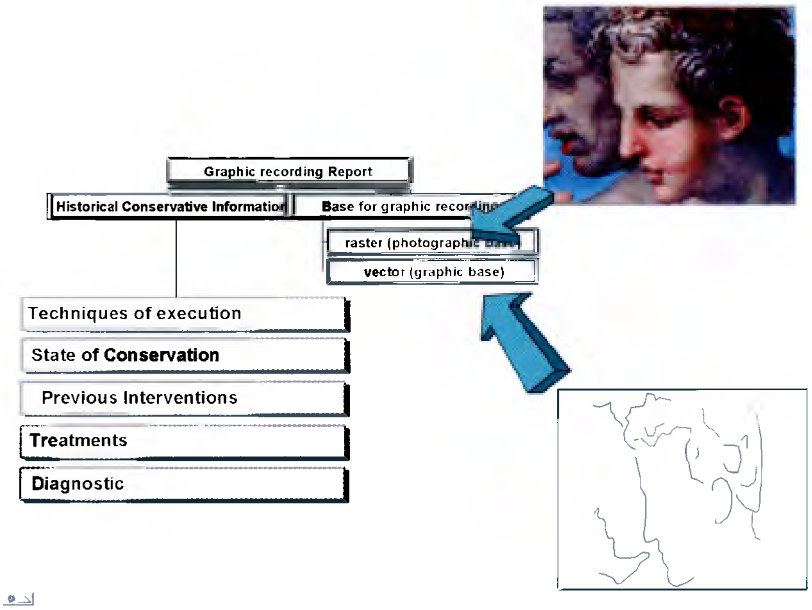


Figure 6. The structure of the graphic condition report and information/base map relationship.

servators carried out the graphic documentation of more than 1000 m^2 of frescoes and mosaics at the Basilica of Santa Maria Maggiore, Rome (Anon., 1997) (See Case Study 1, at the end of this article).

The software structure was integrally tested in two educational worksites at the Church of Santa Cecilia in Trastevere, Rome, involving Art Historian D. Radeglia; Conservation Specialists F. Capanna and A. Guglielmi, with M. Gorini and M. Sangiorgio responsible for base map preparation; A. Rubino responsible for photographic documentation; Documentation Structure by F. Capanna and CAD development and customization by G. Buzzanca. One result was a booklet produced with instructions on the customized AutoCAD menu for educational use. (Buzzanca and Capanna, 1998)

Other complete works, some based on different software releases, were subsequently implemented, including the documentation of the reliefs of Angkor Wat, Cambodia (See Case Study 2, at the end of this article).

In addition, some groups of students have used AutoCAD customizations for the graphic documentation of site-related research projects in their diploma theses (Orrù, 1995; Attura and Zelli, 1997; Billi, 1997; Cici and De Riso Paparo, 1997; Attura *et al.*, 1999) (Figures 3 & 4).

All the examples described were based on AutoCAD versions 12 or 13, and basically succeeded in, as far as possible, reproducing traditional paper documentation techniques in digital form.

Nowadays, limiting digital documentation only to quality printing is clearly nonsense since paper is only one of the possible media. During a study period (Nov96/Apr97) at the Getty Conservation Institute (GCI) in Los Angeles, California (USA) - along with the GCI Documentation Project, there was considerable debate on the significance of digital documentation. The occasion for this was the work carried out during the compilation of the condition report on the Siqueiros mural in Los Angeles (Bishop, Gray and Palumbo, 1998; Bishop *et al.*, 1999; Buzzanca, 1997). The team comprised G. Palumbo (Documentation coordinator), M. Bishop (Research coordinator), L. Rainer (Senior fellow), I. Sen (Intern), A. Bass (Research fellow) and C. Godlewski (Research associate). G. Buzzanca was responsible for software customization and training.

Apart from a complex conversion of the entire documentation structure to AutoCAD 14, that was integrally modified, there was also the development of the system in which each graphic sign was allotted its own layer. In this way, each phenomenon was recorded on a separate layer and the structural hierarchy of the documentation system was driven by a system of file nomination. This translated into the world of conservation what has already been defined for computer application in the field of construction, with a series of rules and standards by the International Organization for Standardization (ISO).

Other recent experiences (Cordaro, 1999) have also used thematic mapping systems that have been elaborated *ex novo* and implemented on high-level software and hardware; these applications used some of the methods and conclusions that came out of the work that has been previously described. This was also a first step towards the integration of different documentation formats in a computerized information system.

There was never any doubt that it would be necessary to set up a computerized information system. Until now, however, computerized systems dealing with complex monuments of artistic and historical importance have usually maintained a separation between spatial information (photogrammetry and vectoral images), textual information (whether more or less structured) and images derived from photographs (raster) (Cordaro, 1999).

When referring to the documentation of the Leaning Tower of Pisa (Figure 5), Cordaro explains in the same article (Cordaro, 1999):

> "Here, instead, the choice was made to set up a system that unified and integrated these different elements. This allowed not only a centralized management of the information but also the development of spatial characteristics of the Tower, the key to accessing the extensive range of data which could contribute towards the description and evaluation of the overall condition of the monument. Such data was in the form of charts, technical reports on measurements and analyses conducted on the monument, archival and bibliographical information, as well as drawings and photographs, whether pre-existent or specially compiled for the project. The final result of this work will be a digital

computerized system that will enable data to be accessed in a variety of ways via a graphic interface. The various types of information gathered from the different sources will be presented graphically on a series of layers which can be superimposed one on top of the other, each layer dealing with particular themes. (...) This model can now thus act as a support for all aspects of the process of documentation: from the emission of data, to research and the verification and comparison of information. The system may be monitored and updated at any time and is independent of commercial standards, though it is able to produce standardized procedures."

FEATURES OF THE CUSTOMIZATION

The graphic representation of an object, like the representation of its state of preservation or the techniques of execution, is achieved through the use of symbols that make it possible to visually represent several aspects of the object in question.

The final drawings should be seen as the tip of an iceberg, since they contain much more than is apparent.

The implicit content of all digital documentation is:

- a glossary of specific terms, phenomena, etc;
- graphic standards and conventions;
- adoption of file and layer naming techniques;
- use of tools for layer management;
- graphic interface customization; and
- relationship between the Object Model and the Information Model;

In fact, graphic documentation is made up of two different models, which are combined. The first one concerns the object as such, and the second one concerns the historical and conservation information, selected and grouped by category. The model is realized by means of graphic symbols, including patterns, symbols and letters, superimposed on the first model. Some proposals for the use of standard symbols in recording the condition of objects have been produced in the last twenty years (Bogovcic, 1981; Varoli-Piazza, 1984; Zverev and Yablokov, 1987; Baglioni *et al.*, 1997). There is not much to add here that has not already been stated.

Symbols and patterns pertaining to the object's historical-conservation condition report are the graphic extension of a list of terms structured according to the categorization system. The base map can be either a photo or a line drawing. ICR's experiences are, so far, only with line drawings (Figure 6).

The file naming techniques have been applied extensively in order to create an indexable database of the drawing. A prerequisite for efficient data transfer and sharing is that all the information in models must be structured and partitioned in standardized ways.

The drawing files have been generated beginning with a standardized template file that contains all the parameters and the structures of the various pre-defined layers. Each layer has been defined in order to receive a single type of information. The data entry operation has been optimized so as to be as independent as possible of the need for computer literacy or special training on the part of the conservator.

A great deal of attention has been paid to visualization instruments (i.e. pre-defined zooming, selective and synthetic views of layers) and the administration of the layers. In this field, the parameters for improvement or adjustment depend on the needs and the input of the conservator. The visualization of the layers also takes advantage of the naming of the layers to permit the user to make choices regarding the visualization of the hatch patterns (i.e. the graphic signs used to indicate a phenomenon), the outlines or both together.

From a technical point of view, all the data entry is based on the use of a number of twin layers in which the construction lines (or the outline of the area occupied by the recorded phenomenon) are distinguished from the hatch patterns that fill these areas (Buzzanca and Giorgi, 1995).

All the operations of copying or transferring objects between layers and the visualization of particular layers during the registration phase have been automated through routines (i.e. an automated series of commands) written in the language of the software selected.

An important part of the project lies in the definition of the terminology and graphic symbols used to classify the various types of alteration, the work techniques used, the evidence of previous restorations, as well as a description of the treatments currently being planned. The terminology for alteration in materials was based on the recommendations contained in NorMaL 1/88 and referring to stone surfaces. In the beginning of the project, also the symbols used to represent these phenomena graphically were based on the NorMaL recommendations, selecting the computer-generated symbols that were most similar to those given in the document. The NorMaL legend, however, was incomplete and only partly applicable to mural paintings. As a consequence, a number of additional terms and symbols had to be created, for which so far no standard exists but that are based on extensive corporate experience.

Moreover, it is possible today to customize AutoCAD menus and toolbars to conform to Microsoft® Office. In this environment, the graphic interface, including icons, toolbars, tooltips and help files, is considerably simplified, providing quick and easy access.

From the point of view of the user, in order to compile the various thematic maps it is necessary to carry out the following operations:

- select the category in the menu bar (i.e. technique of execution, state of preservation, previous interventions, diagnosis, etc.);
- select the layer on which the data will be recorded;
- outline the area in which the data will be inserted, using a closed polyline;
- select the hatch pattern that will be inserted in the outlined area; and
- select the closed polyline (or an internal point of the area) and apply the hatch pattern.

This sequence guarantees the correctness of the input operation.

ADVANTAGES VS DISADVANTAGES

By using a portable computer on site, it is possible to transcribe the data directly into the computer while observing the wall painting, thus eliminating one of the steps necessary in the manual operation, which is usually carried out in two phases: first recording on paper on site and then collating and drafting in the studio.

In some cases, a laptop computer was used on site by the documentation team, whereby one operator observed closely the surface of the wall painting, while the other was in front of the computer monitor. The presence of the operator close to the wall painting was useful, since it allowed rapid survey and accurate verification of the damage, and thus the recording of the data (Figure 7).

It is not always possible to have a portable computer on site. In contrast to the undoubted and numerous advantages of the portable computer (this is not the forum to discuss these), it should be noted that in some cases unfavourable environmental conditions could make the use of a portable computer difficult (surfaces with difficult access, limited battery life, dust, etc.). The use of paper, for the recording phase, can be more versatile in these cases, even though there is sometimes a loss of precision, mainly due to the addition of one step in the process, i.e. the translation of data from an analogue form to digital.

A critical analysis of the examples allows us to appreciate the advantages that digital recording, presentation and archiving offers with respect to the traditional manual techniques.

These advantages can be summarized as follows:

- speed, precision and homogeneity in the recording phases (i.e. the representation of the information does not depend on the graphical ability of the operator);
- easy exchange of information in the recording phase, according to predefined formats; this allows simultaneous work on site and rapid collection of information;
- immediate visualization of the sets of information collected, allowing ongoing quality control of the input;
- the possibility of interactive analysis of the information (collected on separate layers using standardized layering systems) through the superimposition and comparison of the mapped areas;
- records are readily available for any kind of final presentation;
- rapid updating of the information (both graphic and descriptive); and
- possible reduction in the costs of documentation (excluding initial investments for purchase of hardware and software, training, customization, etc.) where the work is well structured and organized.

Information technology is in continuous

development, and hardware and software systems are increasingly complex. However, economy, simplicity and absolute transparency to the customer must be the essential characteristics of any system, both in the recording and managing phases. Currently, we have seen a progressive migration from CAD applications towards a 'mixed' environment, where the different classes of data (and formats) tend to look for common reference protocols, such as those provided by GIS applications (Buzzanca, 1999).

Computer enthusiasts, however, often completely ignore negative aspects, such as:

- need for environmental conditions that do not harm the hardware;
- costs of the hardware and software (i.e. acquisition and frequent upgrading or substitution);
- continuous data upgrade to guarantee long-term workability, modifiability and accessibility;
- time and cost necessary for operator training; and
- limitations in the viewing options of the information on the computer screen (i.e. the resolution of the screen allows good visualization of a drawing or the information only for small areas. The restriction to a delimited pixel area (i.e. 1600x1200) is often insufficient for visualization of more general views.

In addition, management of the digital documentation has associated problems, most of them related to the need to involve computer or documentation specialists, who must have:

- knowledge of the structure of conservation documentation and the capability to work in close collaboration with the conservation specialist;
- skill in the structuring of digital formats;
- skill in data transfer to and from other systems, including back-up procedures and continuous data upgrade, and
- knowledge of archival conservation of hardcopies and digital support techniques.

CONCLUSIONS

Experience has shown that menu customization and development of short-cut macros are an effective way to reduce the need for in-depth learning of complex programs for the recording phase. Experience also shows that this approach reduces errors in data entry by promoting a greater degree of accuracy and efficiency, and makes the operation accessible to a large number of users, not least because of its inherent user friendliness (Bishop, 1999).

Menu customization has made it possible to operate the software with very limited technical training because all complex command sequences are performed automatically by previously-prepared macro strings. In most cases, conservators have been able to work properly after only three or four days of practical training. In the recording phase, it is possible to use 'light' versions of the complete CAD software. It is only necessary to ensure the use of agreed standards and the possibility for full transfer of data to the full-implementation CAD software.

The recording phase should be the responsibility of the conservation specialist, and the acquisition of data for analytical and documentary purposes must be performed on site. It is better to record information about the materials, structure, past history, current condition and environment of the cultural property directly through digital instruments, avoiding translations.

The computer instrumentation should

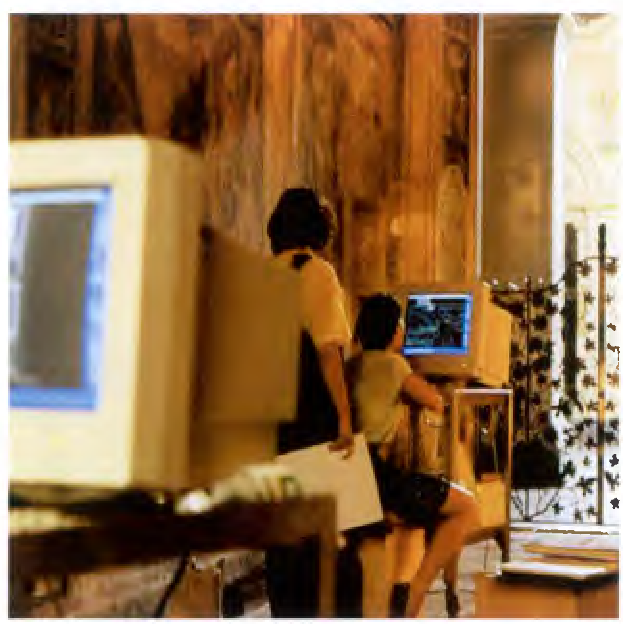


Figure 7. While working in a chapel (Rome, S. Cecilia in Trastevere), it was possible to use a desktop computer with a trolley and record the phenomena beside the painting.

be conceived in terms of small workstations with user-friendly interfaces that, with minimal training, can be used by the conservator in charge of recording.

The rigorous adherence to standards (file naming, layer naming, patterns, symbols, etc.) is a fundamental necessity when working with large amounts of information. All use of computers requires the use of a language that will act as an interface between the operator and the computer: a language and, of course, a grammar. This is the task of the computer-*cum*-documentation specialist. In order for a language to be simple, it must have a strong structure and classification reflecting the 'real world' and yet at the same time allow detailed examination and analysis of each element (Buzzanca, 1999). This is the situation that exists also for non-graphical documentation (textual databases) carried out in ICR in 1999 for final thesis preparation by students (Blanco Mateos, Minoja and Prestipino, 1999; Faleschini and Scioscia, 1999):

> "But what are the standards in the context of the application of computers to cultural heritage? They are a mixture of the various rules that have been established in order to give structure to the information that has been compiled respecting a grammar and syntax that is inherent in every element and have the most appropriate terminology and means of communication.
>
> This collection of rules, if set out and recognised by a group of experts, should have the aim of giving an increased level of coherence (...) to the working methods of those who produce the graphic documentation" (Corti, 1992).

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The following two case studies illustrate applications and adaptations of the AutoCAD-based graphic documentation system developed by ICR.

(Case study 1)

15

USE OF A STANDARDIZED APPROACH FOR A LARGE-SCALE COMPUTER-AIDED GRAPHIC DOCUMENTATION PROJECT AT THE BASILICA OF SANTA MARIA MAGGIORE IN ROME

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Freelance Conservator-Restorers, Rome, Italy

Figure 1. Exterior of the Basilica of S. M. Maggiore.

BACKGROUND

The conservation-restoration project reported here was executed in the Basilica of Santa Maria Maggiore in Rome. The work was financed by the J.P. Getty Foundation and carried out by a multidisciplinary team of professionals directed by Professor A. Nesselrath, (Department of Byzantine, Mediaeval and Modern Art of the Vatican Museums). Professor N. Gabrielli (Department of Scientific Research of the Vatican Museums) coordinated the scientific research, with M. De Luca (Head of the Restoration Laboratory of the Vatican Museums) providing technical direction. The work was carried out by restorer Bruno Zanardi.

The investigation and graphic documentation of a complex and huge scheme of decorated architectural surfaces presents special problems regarding the management and accessibility of the large amounts of information generated during such work.

The restoration of the mosaics in the apse, the main arch and the central nave, along with the wall paintings in the transept and central nave of the Basilica of Santa Maria Maggiore (Figure 1) in Rome provided an opportunity to verify the efficiency of an operational methodology for the documentation of a large decorated surface area – in this case, about 1000 m^2.

METHODOLOGY

Within the framework of a global and specific study of the surfaces, the aim was to establish an operational method that would simplify data recording while facilitating consultative access to the vast and varied information obtained.

To this end, from the outset, the plan was to develop a computerized graphic documentation system designed and implemented by the authors.

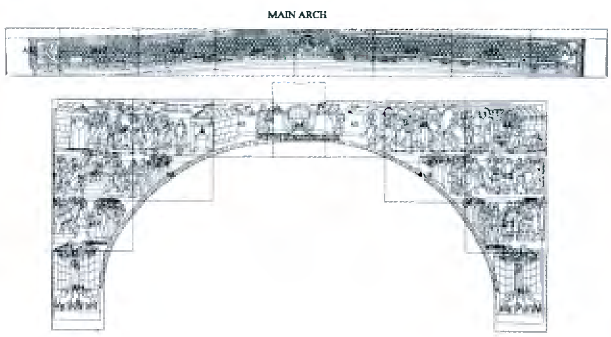

Figure 2. Base map subdivided into squares flagged by a number and letter for rapid localization.

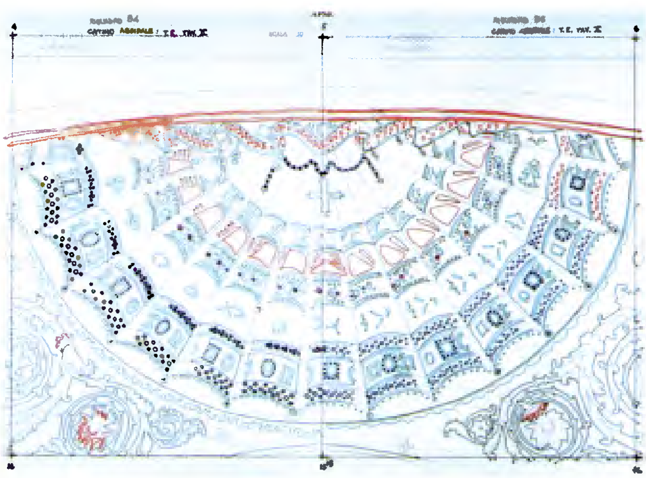

Figure 3. Graphic documentation carried out by hand on site with acetate sheets placed on top of base map.

The vastness of the areas to be studied and documented, as well as the complexity and variety of the data to be handled, led to the selection of CAD software (AutoCAD 13, and, on an experimental basis, AutocadMAP and GIS Technology). This software made it possible to verify the basic graphic representations and to organize the data in a functional manner according to the type of documentation being dealt with, by using transparent overlays, analogous to the acetate sheets used for manual mapping on site.

For the registration of data, customized menus were provided, based on those developed during a study of documentation techniques, carried out by Giancarlo Buzzanca (Istituto Centrale per il Restauro), who acted as project consultant. The menu files were organized according to the requirements of the mosaics and wall paintings under examination.

As large quantities of graphic data, first recorded manually on paper, had to be entered into the computer quickly and easily, the work was organized in the following phases:

- setting up of an extensive and detailed legend of symbols and categories which would cover all the sectors required to document the techniques of execution, the condition, previous restoration work, and scientific diagnosis;
- creating the line drawings (i.e. base maps) to be used as models of the object, by making use of a combination of different methods:
    - ➢ manual measured drawings, transferred into the computer by scanning and vectorization;
    - ➢ line drawings made with a computer system on orthophotographs, following measurement of the main features of the target area in order to size the graphics correctly (i.e. to rectify them);
    - ➢ photogrammetry techniques (effected by FO.A.R.T s.r.l., Parma) used for the curved surfaces of the apse walls;
- subdivision into squares of the base maps, flagged by a number and letter for rapid localization (Figure 2);
- adoption of a 1:10 scale as the most suitable for visual analysis; this allowed the use of base maps printed on A4 paper and made it possible to represent the main features of very small areas;
- manual recording of all data obtained during on-site visual inspection, on acetate sheets laid over the single squares of the base map, and representing the various types of data with outlines in different colours (Figure 3);
- scanning and vectorization of all the information recorded on the acetate foils and identification of different area phenomena by means of different coloured overlays;
- mosaicking of all the data collected for each single square followed by processing of the corresponding final tables, which provide various

levels of information for the entire surface (Figure 4).

The software described above proved to be particularly useful in producing graphic documentation in the context of an ongoing conservation project, because of the following features:

Calculation of area

It is possible to quantify information, such as the area covered by a particular type of deterioration, or the presence of a constituent material in the original work, or a former conservation intervention.

This contributes significantly to the planning of the conservation project. In the case of the Basilica, it facilitated the design of a methodology that differed according to the type of material used in the mosaics (glass paste, stone material, gold and silver tesserae) and the techniques used to produce the wall paintings (fresco or tempera).

Use of overlay techniques

The use of overlay techniques proved very useful in all phases: recording and handling data and studying the results. It enables the simultaneous and comparative study of different levels of information.

For instance, data obtained from direct visual observation can be compared with previous documentation on paper from the archives of the Vatican Museums. In the case of the Basilica, this archival information consisted of the graphic documentation carried out directly onto detailed photographs during restoration work in the 1930-40 period. These consisted of large-format B&W photographic prints at approximately 1:5 scale, onto which mapping was done using coloured ink pens. These mappings were retraced manually (using coloured ink pens onto acetate foils) and then scanned and vectorized. Following this they were dimensionally corrected to be in conformity with the new base maps, saved on a separate layer and compared with the mapping of the actual situation. Finally the data obtained by the comparison of the two situations were incorporated into the maps of former interventions (Figure 5).

Scanning and vectorization of manually recorded information

Scanning and vectorization of all the information recorded manually, with allocation of different coloured screens and layers to the different area phenomena recorded, allowed:

➢ confirmation of the presence of many nails in the apse wall mosaic, dating from the original construc-

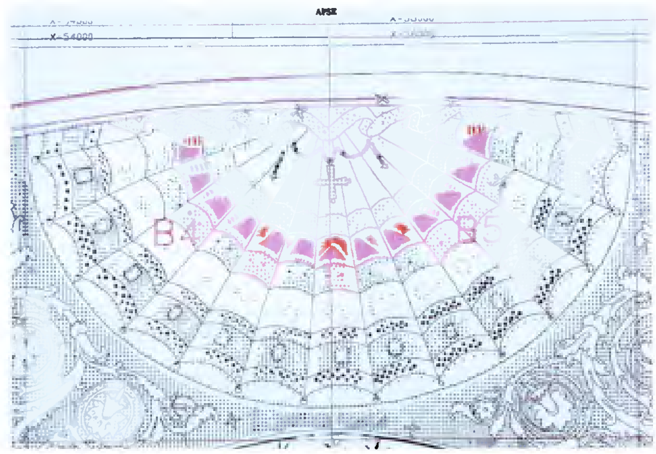

Figure 4. Computerized graphic documentation carried out through the registration of data from previous on-site documentation.

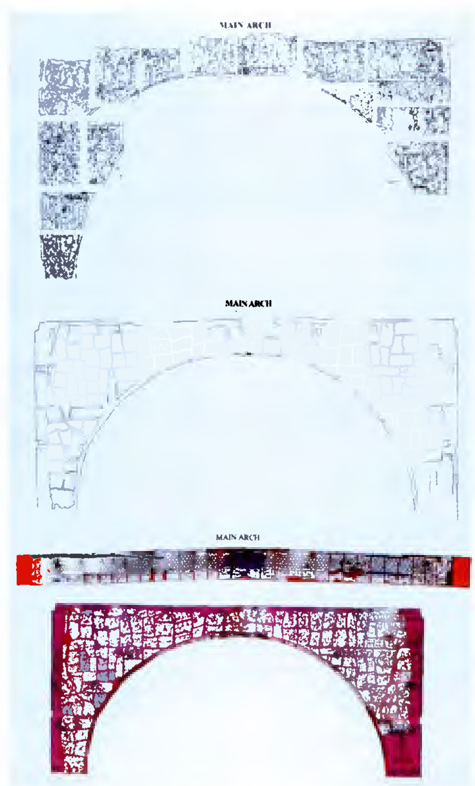

Figure 5. Operational sequence for the realization of the final table about previous conservation work: drawing obtained by scanning and vectorization of data from graphic documentation carried out in 1930-40 regarding the conservation work (detachment of mosaic); - final table result of direct visual observation compared with graphic documentation carried out during conservation work in 1930-40.

tion technique and not from later restoration work;
➢ clear distinction between the original surfaces and the restored areas through the overlapping of the maps relating to the techniques of execution and those relating to previous conservation interventions; and
➢ understanding of possible causes of deterioration through the simultaneous examination of altered areas and the materials used (for instance, the loosening of mosaic pieces caused by the alteration of metal elements beneath them, or the presence of efflorescent salts caused by unsuitable restoration materials).

The opportunity to organize and follow through all the phases of the project enabled the authors to acquire an overview that proved very useful in determining the various types of deterioration in the different areas of an extensive surface, providing a unique tool for the identification of the causal factors.

CONSERVATION PHASE

Once the preliminary study phase had been completed, the conservation proper began in February 1998, thanks to new funding made available by the J. P. Getty Foundation and the Basilica di Santa Maria Maggiore itself, under the auspices of His Grace D. Lewis, and was completed in September 1999.

The work involved all the mosaics in the apse, the main arch and the central nave, and wall paintings in the central nave of the Basilica, supervised by the Vatican Museums.

The task of coordinating the conservation work on behalf of the restorer, Bruno Zanardi, after having supervised all the stages of the graphic documentation, enabled the two authors to verify the functionality of the computer software system chosen during the preparatory phase. The ease and precision of access to the computerized graphic documentation facilitated the project in many ways. After a year, it was possible to detect changes in the state of deterioration, making it necessary to integrate the graphic documentation with an updated condition record before the intervention started.

The site documentation relating to the new intervention was facilitated by the speed of execution, and by the use of thematic tables (created during the preliminary study phase) as the basis for graphic reference, printed on standard A4 sheets. With the same method used previously for recording of preliminary investigation data, it is possible to computerize data relating to the intervention carried out.

Collaboration between people with different professional skills, the analytical tools provided by the computerization and the possibility to compare and elaborate data gathered from the examination of the entire surface involved, have resulted in a significant reduction in the time and cost of the intervention, as well as collecting a large amount of technical data relating to the composition and history of these important works of art.

In addition, the methodology chosen for the project made it possible to set up a database by organizing the information in a structured way. The database, still not completed, will contain all graphic and photographic documentation relating to technical-conservation and scientific data. This will permit queries to be made about the original materials or the working techniques, about former restoration work or about the recent intervention (for example the description of materials used, related photos and scientific investigations, the state of conservation before intervention, its graphic record, and thus the location and extent of decay).

CONCLUSION

Both the methodology and software used, as well as other, commercial software, provide the facility not only to carry out graphic documentation such as that described above, but also to organize data collection by creating a database. The use of such an instrument, together with a common effort to define a standardized methodology, could result in a much more ambitious project, which would be the creation of a centralized database dedicated to the conservation of cultural heritage, to which everybody could contribute with their experience and which would speed up enormously the interchange of new experience and information.

Indeed, one should not overlook the enormous potential offered by these new communication technologies and how much they could increase our knowledge in a field in which the dissemination of methodologies and results is crucial.

(Case study 2)

15

THE DOCUMENTATION OF THE CONSERVATION OF THE SANDSTONE RELIEFS AT ANGKOR WAT IN CAMBODIA

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The Temple of Angkor Wat in Cambodia is one of the most important cultural heritage sites in South-East Asia and has been on the World Heritage List since 1992. Since 1996, the University of Applied Sciences, Cologne, has been running a project, led by Professor Dr Hans Leisen, which aims to conserve the carved reliefs that render this temple so unique. There are more than 1 900 bas-reliefs of the female divinities known as *apsaras* or – more correctly – *devatas*, and when planning and organizing the systematic technical conservation of such an enormous quantity of reliefs, the correct and meaningful documentation of the work plays a key role.

For the full recording of the research and the conservation operations carried out by the conservation team it was necessary to divide the information into five different categories:

- State of Preservation (Deposits);
- State of Preservation (Decay);
- Previous Interventions;
- Technique of Construction; and
- The Conservation Operation.

This meant that at least 9 500 drawings would have to be prepared and archived if the operation were to be accurately recorded.

Clearly, if this type of work were done using traditional documentation techniques of paper and coloured pencils, too much time and personnel would be needed. So it was decided that, instead of scale drawings, it should be possible to use high quality, black-and-white photographs as a reference background for the documentation. Professor Poncar and his team were already carrying out the photographic documentation of the temple, and scanned photographs were passed on to the conservation team.

The software that was eventually chosen for this documentation was AutoCAD 14. One important feature of AutoCAD 14 was the facility to use digital photographs. It is now possible to use photographs as a background for the drawings and this seemed like an interesting solution to the problem. However, the photographs are very high resolution and there was the risk of overloading the hard disk. The solution was the inclusion of the photographs as external reference files (Xrefs) so that it was possible to temporarily download the photo from a CD for the recording process without filling up the hard disk.

It was therefore decided that a specially adapted version of this technique might be the solution for this problem. Consequently, with assistance from Giancarlo Buzzanca of the ICR in Rome, the AutoCAD 14 program was customized around the very specific needs of the site at Angkor.

Since one of the principal objectives of this type of operation is the training of local operators so that the operations can continue in the future, the AutoCAD programme had to be radically simplified in order to make it accessible to local conservators with only basic computer knowledge.

The premise for the documentation was that the data should be recorded easily and accurately, and that the subsequent reading and analysis of the recorded data should be simple. It was therefore necessary that each data type recorded be viewable either individually or together with other data recorded. The idea was that if each type of information were recorded on a separate layer, that it would be possible to include or exclude layers as appropriate, and in this way to view the data in any number of combinations. This would mean that, should the viewer decide to compare, for example, the amount of stone subject to flaking with the amount of the same surface treated with the consolidant, it would be possible simply by clicking the right buttons.

The job was therefore to write a series of macros that would be attached to specially prepared buttons that would mean that when the operator recording the data clicks on the button, he automatically turns off all the layers except the one allotted to that type of information, turns on the correct pen colour, scale, hatch pattern and so on, without having to worry about what the computer is actually doing and without having to carry out five or six different operations. This was a lengthy business, since eventually 200 layers were used for the full documentation, but gradually a working menu was prepared and in 1997 it was first tested at Angkor.

Figure 2. Training local staff to carry out on-site documentation.

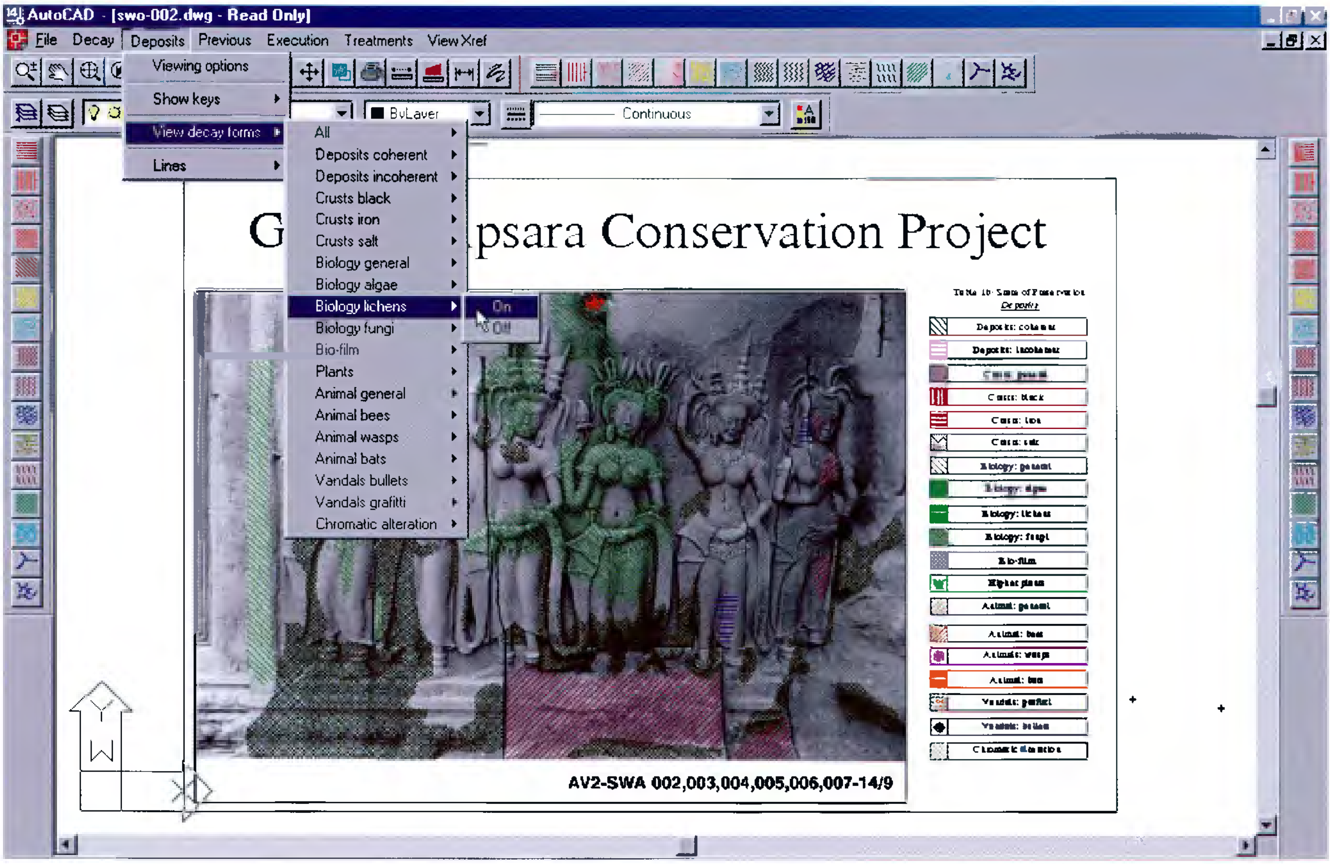

Figure 3. An example of a drawing in use showing the pull-down menus used for visualizing the image and the recorded data.

The exercise was extremely satisfactory, partly due to the successful simplification of the program and partly due to the quality of the local Khmer operators, who succeeded in learning this documentation technique within a week.

The recording of the data continues, with occasional modifications, and is archived digitally on CDs. Recently, printouts were prepared of the full documentation and these have been archived at the University in Cologne, where they will also be photographed and subsequently recorded on transparency film. This is because film is the medium that is least likely to alter in time. The digital medium is that which will be the most useful for researchers, since it remains interactive, but since it is a medium that has only been in use for a relatively short time, it is also necessary to consider the most proven form of archive material for the sake of posterity.

This form of documentation has been successful for a number of reasons. The principal strength is that it combines standard documentation principles with a new element, that of the interactive viewing and superimposition of the recorded information.

This means that the documentation becomes more than a simple record of information: it becomes an analytical tool as well. Furthermore, the simplification of the program makes it accessible to operators with minimal computer skills. The problems remain those associated with the high cost of the software and the fact that it is not a saleable product, since in order to satisfy the specific needs of each individual site or case, the application must be specially customized by a technician with an intimate knowledge of program customization as well as an understanding of conservation activities.

16

GIS AND CAD TOGETHER AS AN OPTIMAL SOLUTION IN HERITAGE RECORDING FOR DOCUMENTATION, RESEARCH AND MONITORING FOR WALL PAINTINGS OR OTHER TYPES OF ARTISTICALLY VALUABLE SURFACES

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ABSTRACT

Correctly recorded digital photogrammetric plans are the best base maps. The use of Geographical Information Systems (GIS) is very practical, but precludes preserving the 3-D context of maps based on architectural views. In contrast, three-dimensional (3-D) computer-aided drawings can compensate for the weakness of GIS when used for documenting pieces of wall paintings distributed in complex building structures. A combination of these two systems helps to ensure that no important documentation aspects or coincidences of phenomena get lost, or remain unclear.

For graphic documentation, preference should be given to database-orientated graphics systems because of their potential analytical power. For the presentation of data, an independent system should be used that provides users with contextual help, perhaps similar to Web-based applications. The author notes the use of a small but powerful photogrammetric system (ELCOVISION (PMS AG)), combined with AutoCAD. For organizing the final digital map, MapInfo Professional 4.01, a desktop GIS for MS-Windows, was used.

KEYWORDS: *digital photogrammetric plans; GIS; heritage recording; wall painting; ELCOVISION; MapInfo; AutoCAD, spatial database.*

INTRODUCTION

An early achievement of civilization – one ascribed to the Greek philosopher Thales of Miletus - was that of a carefully sketched drawing keeping the same geometric proportions of an object as observed in the real world. Important consequences of this were shown in later history: Those who could draw a small plan of a big town, captured it. Others who drew a plan of a fortress and built it, had the potential to preserve their life and pass their heritage on to the next generation. Currently, a real indicator of power is the ability to produce Geographical Information Systems (GIS)-based maps of the world, made using remote-sensing satellite technology. A digital map can answer a lot of questions concerning aspects of a conservation project and this is the main reason it is used in graphic documentation.

There are three crucial criteria to be satisfied in responding seriously to conservators' demands for appropriate computer-based graphic documentation, namely:

- Respecting traditional map conventions for spatial representation.
- Assigning priority to database-orientated graphics.
- Enabling interactive contextual information access.

These will be considered further in the following sections.

MAP SPATIAL CONVENTIONS FOR ARCHITECTURAL VIEWS

At the start of any project, agreement should be reached concerning the approach to be adopted. It means defining the typology of the graphic equivalent of the physical object. Popular GIS systems concentrate on distribution of objects in the horizontal plane, using geo-referenced overlays of information categories. In the past, the plan documentation of wall paintings has usually taken the basic form of two-dimensional (2-D) map stacks, which are views of the unfolded flat wall that only appear in three-dimensional (3-D) models. Following this conventional approach, in the GIS model space we let the maps lie on a flat, horizontal 2-D surface. In doing this we lose any direct 3-D spatial context of the object's surface distribution. However, it is essential to include the 3-D references of every point for each surface area in the project.

The 2-D appearance of the wall painting surface as given by GIS, matches traditional conventions of imaging architectural objects in term's of a bird's-eye view. That is because GIS systems have been developed primarily as a mapping tool for global geographic purposes. In contrast, for a conservator, an elevation (vertical) view of the wall surface normally has a higher degree of usefulness than a horizontal architectural plan of the building. Nevertheless, for a single architectural surface, GIS can be also an excellent tool for material assessment and condition recording in map form.

Only computer-aided design (CAD) is able to provide the spatial context, providing the 3-D point of view that we need in going to build documentation structures. For wall paintings in a building, the spatial location of surface areas is essential, as documented mural painting ensembles are often extremely complex surfaces, distributed in and around architectural objects. As a consequence, it is easy to understand how difficult it is to give the idea of the surface slope on a series of unfolded drawings of a painted dome, or to correlate this slope with decay phenomena such as 'the deposit of foreign material' or 'infiltrations of rainwater,' without having previously constructed a 3-D model.

The problem is complicated even more by the complex geometric structures of many vaults. The orthogonal view from bottom-up gives us a base look at the simple ceiling surface, if the vault is not too much dismembered, of course. In the case of a dismembered surface, only a series of flat projections with correct surface proportions, collated into one map, can build a 2-D base map for GIS. Occasionally the map edges will divide continuous surface structures (e.g. a continuous area showing salt efflorescence), which will then appear in the database as two records. This can cause problems when GIS analytical tools are used in a conventional context for counting phenomena (objects) and sorting principal damage areas. This is one of the weaknesses when 2-D systems are used for describing 3-D objects. Such piteous confusion can be obviated by using desktop GIS software, coupled with a lot of analytical power and an easy-to-use and understand connection to a database. These advantages offered by CAD 3-D systems seem not to have been yet exploited fully to satisfy conservators and other scientists involved. Some powerful features are offered by MapInfo 4.01, with its option to project flat views onto a spherical surface (MapInfo Corp., 1992-94).

Compared to traditional abstract images drawn on paper, digital drawing in CAD offers some advances that can be seen as significant advantages when approximating the complexity of objects in the real world. It can be 3-D, has the right scale (1:1), and is organized as a spatial database. Its digital graphic elements can be linked with text attribute information that can be freely recalled.

Topographically correct and scaled digital base maps are high-end solutions and a valuable technique, together with carefully done manual drawings. The principal goal in preparing such a base map for an object is to obtain a graphic equivalent of the real object. As the object we look at often cannot be fully seen in one view, we generate more views from different observation points.

Only CAD combined with a powerful photogrammetric system (Leitner and Szambelan, 1996) gives us topographically correct and scaled base maps, based on the author's experience with the ELCOVISION system (purchased from PMS AG, St. Margarethen, Switzerland), and only the CAD graphics capability is able to position the maps and any other data correctly in 3-D space. This is a very important aspect of documentation for the future, which probably will make more use of Virtual Reality Modelling Language (VRML)-like structures, expanding our ability to interact in a 3-D space based on what the real, documented object looks like.

The first step in developing the CAD treatment of the surface object is to establish a kind of 2-D prototype drawing with space allocated for every possible data entity that could be associated with the project. To identify layers, it is very useful to develop and consequently apply a hierarchically ordered, open layer nomenclature. The role of the prototype drawing is to avoid having to spend time copying default project variable values into all new drawings, and to guarantee no errors in layer names.

The legend has the function of correlating 'signatures' (i.e. graphic signs observed) with the catalogue of well-defined phenomena. Glossaries give us the possibility of defining different manifestations of the same phenomenon. In each project, an actual list of all mapped phenomena should be prepared, and the layer structure should be expandable because unpredicted new phenomena or possible subsequent repeat records come into the next layers. The database of conservation parameters that can result in a list of mapped phenomena and number of layers is not the same as the spatial database present as the background structure of the digital map in GIS form. There will always be variation from one project to another as to how the whole area of interest, encompassing the totality of decorated surfaces in the different buildings or parts of the building, will be divided into map modules. It is indicative of well-organized documentation if the list of separated plan entities obtained through division along architectural shape or iconographic themes results in a similar structure of project data directories on the hard disk.

A graphic documentation ensemble should contain a clear structure of local coordinate systems. Large, complicated architectural forms in 3-D CAD drawing usually consist of smaller blocks, which have their own defined local coordinate systems. They can be oriented parallel to the flat parts of model, approaching the real surface. Hierarchical organization of local coordinate systems should end in one main system (sometimes called a world system) which joins the project data with external geodesic measurements, including those derived from use of Global Positioning System (GPS) technology. As far as the author is aware, there is no unified convention for the use of one, generally proved coordinate system that matches higher geodesic standards in many countries. Related to local conditions, with the hierarchy of local coordinate systems, the CAD drawing stores the spatial distribution of map entities within the project.

DATABASE ORIENTATED GRAPHICS

This implies a drawing or image in a form that provides the possibility of connecting graphic elements to database attributes, text and multimedia or network links. Such a drawing or image has its own or relates to a higher coordinate system. Establishing a spatial database for the whole conservation project, particularly for large-scale objects like wall painting, with significant information density and where the results of research will appear at irregular time intervals, seems to be a reasonable approach to graphic documentation. Instead of forcing popular but unprofessional systems to achieve the highest quality of image reproduction, we should use GIS, with its advantage of access to a spatial database, and similar printing quality. It is worthwhile promoting wider use of such organized graphics for documentation purposes in conservation. Many current commercial GIS and Local Information System (LIS) software products match the standards of database-orientated graphics (the most well known names are AutoDesk, ESRI, MapInfo). Using thus-structured graphic systems, we have at our disposal considerable analytical power. Compared with the majority of desk-top publishing (pre-press) applications of computers that lack spatial referencing, there is much more flexibility in editing maps, with the prospect of continuing future usefulness of the graphics. These are important factors in any documentation scenario.

Spatial databases bring enormous advantages for virtual map manipulation when compared with normal computer graphic images used for documentation. We can have a look at a mapped object choosing various parameters and their signatures. It does not affect the original data. There is no more need for repeated drawing upon any change. Any possible map remains accessible for the future, based on the data recorded once and maintained. The use of a spatial database therefore is very practical and spares much time.

GIS systems offer the possibility of thematic maps and use of geographical operators, thus providing tools for searching for hidden phenomena correlation. Thematic maps can show us various levels of intensity of the same phenomenon through colour graduation, which can be interactively changed according to values in the database. Geographical operators, such as 'containing,' 'within,' 'entirely within,' 'buffer of,' can be used to identify and extract endangered areas, to look for coincidences of phenomena that are suspected of being correlated in some way, or to estimate limits for urgently needed intervention.

If recording sessions are repeated several times, there is the possibility of establishing time-series data sets amenable to statistical analysis, and to monitor the damage process and its pace.

A promising general trend in decision making for computer application, especially in the field of wall painting documentation, is the priority given to graphics organized as a database, taking advantage of the flexible way in which one can use GIS systems. This can be much more efficient and future oriented than creating provisional solutions using DTP software (e.g. Corel Draw, Micrographics Designer, Adobe Products) because of their lower (?) price and initial user friendliness. The initial advantages of these program, which are really excellent tools for publishing purposes, and partly also for visualizing the work, will often become a trap if someone intends to achieve an integration of data and share information at national or global levels. Several GIS systems offer, compared to popular computer graphic systems, a much better functionality and the possibility to integrate different types of data, and seem to make better use of recently available hardware standards.

INTERACTIVE CONTEXTUAL INFORMATION ACCESS

The role of this is to provide us with an increasingly comfortable tool for making use of documentation archives. Objectivity of graphic documentation is probably not achieved by high quality reproduction only. In most cases, perhaps excluding classical sculpture exhibits, cloning objects won't satisfy our wish to be well informed. Documentation finds often its objectivity in the flexible way we can access it. Not all persons have the acrobatic skill of experienced CAD designers. A dedicated information system is a hardware+software structure that allows interested users, including less-experienced, to operate more easily in the archive environment. It consists of pre-defined presentations for main themes, and interactive parts where the contextual help can appear if someone is hesitant in choosing a menu option.

Such support systems can be individually created for each conservation project, or could have a more standardized background structure, that should be based always on current browser versions. The system should work without the original licence-protected CAD or GIS software, i.e. it should be possible to view the data with simple Viewer software that can be downloaded for free from the Internet.

There must be allowance for both multimedia storage (on CD-ROM) and network communications (through the Internet), implying the availability of double sets of data – both higher and lower resolutions (i.e. fewer bytes). It means also that simplified general views for large-scale and precisely defined details of microstructures should be included and accessible through the same mouse-click. All included: giving a feeling of breaking limits of precision levels and scale. It is the way we like to see something, and it's the way the human brain seems to work.

In the near future, the standard for presentation of project data will move toward interactive contextual access, as defined in dedicated information systems. We shall probably be able to obtain information through a network terminal with only minimal time lapse. An important point is to define the access rights granted to users. Currently, there is a dynamic development of WWW- and HTML-technology-based applications being used for presentation of network resources. It should be welcomed, extending the scope for application of such presentation standards to include also the field of conservation.

In conclusion, it could be said that today only GIS and CAD working together can satisfy the demands of conservators for the very highest quality graphic documentation. At the present state of technical development, the functions of both systems complement each other. This is partly because both systems are structured to store data and to describe real objects in different, specific and in fact complementary manners. There are two concepts: the CAD data model and the GIS data model. Both CAD and GIS have developed as systems based on information technology, and have been specialized as commercial software products. In the author's opinion, they deal better with the complexity of interdisciplinary work such as wall painting documentation (and art work documentation in general) when applied in parallel.

Separately used, CAD can be very useful when the documentation ensemble should include the architectural inventory, together with any pre-existent studies on paper, or stored in digital format, particular in 3-D. Similarly, if it is to be used for some reason in building engineering or scientific analysis for conservation purposes (e.g. for computing material strength, thermal flow, humidity or soluble salt potentials). Some (3-D) spatial coincidences of phenomena observed on a mural surface (two-sided wall or ceiling) can be better recorded, documented and interpreted using CAD data models. Other examples are graphic data relating to fluctuation of air humidity, moisture measurements, site-specific insolation, or location of core samples. Also the chronology of the building and changes in an iconography programme are sometimes better explained if previous parts, even if actually no longer extant, can be virtually modelled into the CAD drawing. The highly sophisticated wish of documenting the location of a photographic camera and its position in 3-D space for every photo could also be satisfied by CAD in a quasi-automatic way.

For such basic documentation activities as visually effecting material assessment, recording visible damage, preparing a conservation plan and calculating areas for treatment, as well as a means of storing the location of samples and photos, GIS is a perfect tool. Organizing spatial data on the 2-D wall painting surface with GIS has several advantages. Some of them are the possibility of using implemented (i.e. originally defined in the standard software system) geographical operators. Actions like buffering endangered areas, identifying and showing coincidences between two or more phenomena, computing areas, choosing all samples from the database within complex areas of interest: all these are examples where simple GIS routines support the user better than non-customized CAD. Additional advantages of GIS are the possibility of generating thematic maps. It is very easy to obtain colour-graded intensity and distribution maps, which are very helpful for visualization of investigation results.

As mentioned before, original operating CAD or GIS software&hardware systems can be too expensive or too complicated for the normal user. The possible future development of operating systems, for which we hopefully wait, will also allow groups with less training to actively participate and produce some elements of graphic documentation to a high standard.

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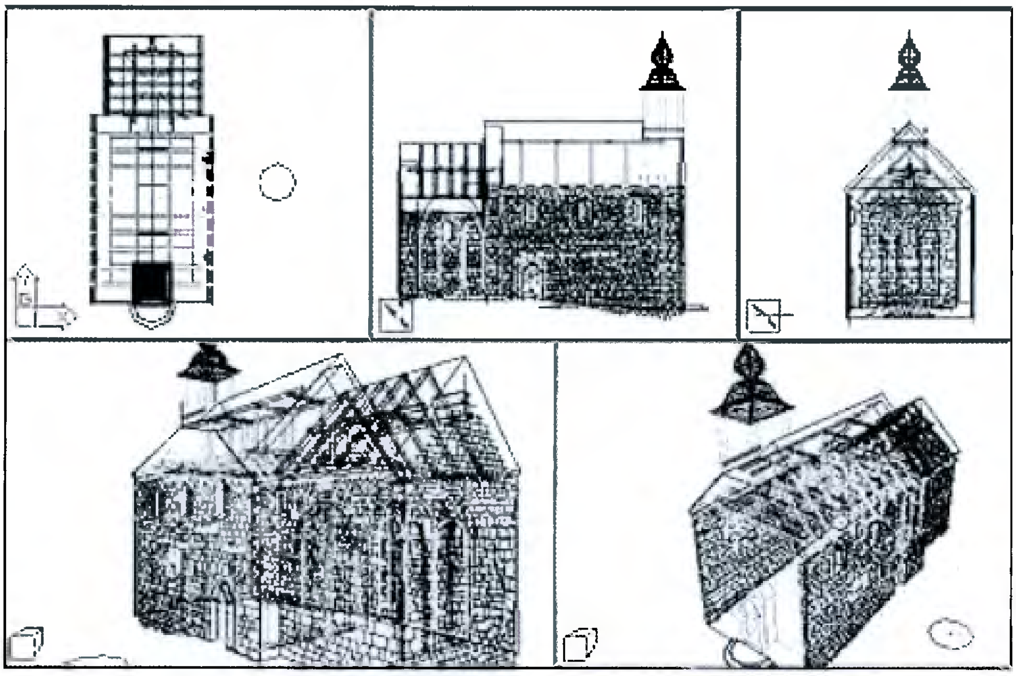
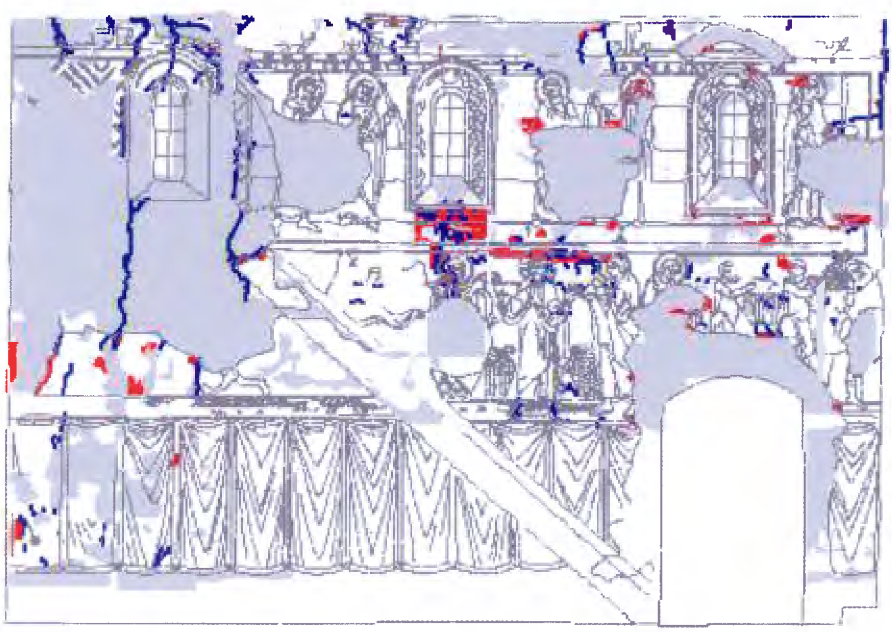
3D CAD architectural model of the romanic church.
Photogrammetric measurements and restitution of external wall structure



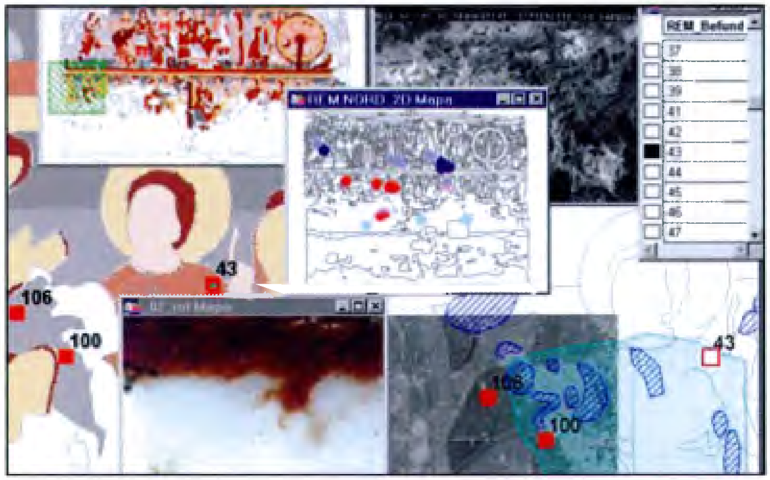
Johanneskapelle, Purgg, Styria, Austria
CAD and photogrammetry: mgr Rafał Szambelan and mgr ing. arch. Marzena Szambelan
investigations: Rest. Heinz Leitner

GIS, Mapping of damages and dangered area on painting surface
Northern wall, Johanneskapelle, Pürgg, Styria, Austria, 1994



Red regions: dangered area with lack of adhesion in original mortar
(investigation: Rest. Heinz Leitner;
GIS: mgr Rafał Szambelan and mgr inż. arch Marzena Szambelan)

Possibilities of GIS based graphic documentation
Interactive digital multimedia map



Northern wall of romanic presbytery, Pfarrchurch, St Georgen ob Judenburg, Styria, Austria.
Results of research program carried out in 1992-95 on the wall painting.
Investigations: Dr Johannes Weber, HSAK Wien, Rest. Heinz Leitner;
Photogrammetry: Dr Michael Gruber TU Graz, GIS: mgr Rafal Szambelan

From calibrated photo to CAD architecture model in 3D
Ruinengrotte, Hellbrunn castle, Salzburg, Austria, 1995
Photogrammetry: mgr Rafał Szambelan; Rest. Heinz Leitner

17

COMPUTER TECHNOLOGY AND THE DOCUMENTATION OF THE RESTORATION OF MICHELANGELO'S FRESCOES IN THE SISTINE CHAPEL - 1987-1994

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ABSTRACT

For the conservation-restoration of Michelangelo's frescoes in the Sistine Chapel (the ceiling and *The Last Judgement*), the Vatican Museums decided to develop a software suite specifically for the collection and digital storage of all data relating to the state of conservation of the fresco before the intervention, and the artist's techniques of execution.
Making use of this software and of precise base maps provided by a photogrammetric survey – carried out in 1985 thanks to the generosity of Baron Thyssen-Bornemisza – it was possible to store in computerized form all relevant information that until then had been recorded manually by the conservators. In 1990, analysis of the ceiling contour lines based on the photogrammetric survey enabled the realization of an exact scale model (1:20) of the Sistine Chapel, interior included. The curved nature of the vault meant that special software had to be used to provide a 2-D projection of the 3-D line drawing of the frescoes that resulted from the photogrammetric survey, and to provide graphic representations as close as possible to the lost preparatory drawings (cartoons) of Michelangelo.
An Apollo DN 3000 graphic workstation was installed on the scaffolding. The graphic software specifically developed for this restoration project was CAD-based and programmed in Fortran. The customization allowed precise mapping and digital storage of:

- surface measurements of the frescoes;
- techniques of execution;
- state of conservation;
- sites of paint samples for chemical analyses and cross-sections with relevant information retrieval;
- precise positional mapping of the photographs to be taken before, during and after the restoration;
- mapping of the censorial draping decreed by the Council of Trent to cover the naked figures in *The Last Judgement*; and
- mapping of the cleaning tests on *The Last Judgement* (March – September 1990).

In nearly eight years of work, approximately 2 Gb of data were accumulated, and the 30 back-up cartridges are now stored at the Art Restoration Laboratory of the Vatican Museums. In 1996, a DXF format translation of all data collected was carried out to provide compatibility with current AutoCAD releases.

KEYWORDS: wall painting; documentation; funding; management; Michelangelo; Sistine Chapel.

INTRODUCTION

During the restoration of Michelangelo's frescoes in the Sistine Chapel (Figure 1) from 1981 to 1994, for the first time a technical information databank was created to record all relevant documentation. The entire project was comprehensively recorded, using various methods.

Both black-and-white and colour photographs were taken before, during and after the conservation work. Some 15 000 photographs were taken of the vault alone, and these are currently stored in the Vatican Museums' Image Library and in the Archives of the Art Restoration Laboratory of the Vatican Museums.

In parallel, a film was made documenting activities. It was produced by Nippon Television Network Corporation, Tokyo, showing virtually the entire restoration process on the vault and *The Last Judgement.* It was shot on 16 mm film, approximately 90 km long.

However, due to the particular importance of this conservation project, it was considered necessary to study and record every single aspect of the painting scheme, using non-invasive techniques wherever possible; this requirement was maintained throughout each stage of the restoration process, with the result that for the entire surface treated (approximately 1 200 m^2) scholars now have access to comprehensive information relating to the technical execution of the Sistine Chapel's frescoes as well as to their state of conservation. Restoration in progress was not graphically documented, given the availability of NTV's detailed filming of the whole conservation process.

To record and hold available all this information in the most precise and detailed manner, use was made of computer technology.

In 1985, the *Direzione Generale* of the Vatican Museums approved a photogrammetric survey of both the ceiling of the Sistine Chapel and *The Last Judgement*, thanks to the generous contribution of Baron Hans-Heinrich von Thyssen-Bornemisza. This survey allowed, through an analytical stereorestitution system, the digital storage and processing of the measurements of Michelangelo's frescoes.

This survey, carried out between 1985 and 1986, was based on a thorough analysis of the ceiling's contour lines, which would enable, four years later, the realization of the first original scale model (1:20) of the Sistine Chapel, interior included. Needless to say, that same survey has been essential for verifying the stability of the monument (Figures 2 & 3).

This photogrammetric survey was carried out by a specialized company in Rome, which later would be entrusted with the development of graphic software intended for the storage and processing of the data obtained from the various surveys.

All derived information, collected and made available both as an electronic database and as hardcopy (1:5 scale on non-deformable sheets), was originally intended for recording:

- the overall plan of Michelangelo's frescos;
- the outline of figures and other painted items;
- altimetry (the so-called contour lines); and
- significant damage to the plaster.

Subsequently, however, the possibility of obtaining a metrically precise line drawing of the paintings prompted the project leaders to also obtain a computer-aided recording of the entire graphic documentation relating to Michelangelo's painting techniques and the condition of the fresco before restoration. Until then, such extensive documentation would have been collected by the conservators themselves before and after restoration, making use of base maps prepared by a draftsman. Even though such base maps were very close to the original frescoes as painted by the artist, they were not as precise as those processed by the computer.

Thus, in 1986, it was decided to install on the access scaffolding for the restoration of the vault, a graphic workstation for the recording and storage on magnetic media of all data relevant to the condition of the fresco and the artist's techniques of execution.

To do so, considering the huge amount of information that would have to be gathered, it was decided to make use of particularly powerful hardware, with software specifically devel-

Figure 1. View of the Sistine Chapel ceiling after the restoration.

Figure 2. View of the original 1:20 scale model of the Sistine Chapel.

Figure 3. Interior of the 1:20 scale model of the Sistine Chapel, showing the ceiling's contour lines based on the photogrammetric survey.

oped for the purpose and easily extensible for any subsequent application. In addition, all these tools had to be user-friendly.

After about ten months of work, the software was ready. The company responsible for carrying out the photogrammetric survey had lead technical responsibility for the technical production, but the whole conservation team collaborated, especially during the preparatory phase for the definition of basic specifications. At that time, no suitable commercial software was available.

At this point, the author was entrusted (by the late Fabrizio Mancinelli, Director of the restoration works, and Gianluigi Colalucci, Chief Restorer of the Sistine Chapel paintings) with the task of assisting the conservators in their studies concerning the condition of the frescoes and Michelangelo's techniques of execution, and for computer storage of all derivative data.

On 23 January 1987, an Apollo DN3000 graphic workstation was installed on the scaffolding; it consisted of:

- a 19" high-definition colour display (1024800 pixels);
- an alphanumeric keyboard and mouse;
- a Summagraphics II graphic tablet with pen to use the software's main menu; and
- a Calcomp 1044GT pen plotter to produce hardcopy output on paper of stored data.

Technical description of the hardware

Apollo was a manufacturing company specialized in the production of hardware mainly intended for providing software and graphic representations. In 1990, Hewlett-Packard acquired the Apollo Company and today continues to produce graphic workstations under its own name.

The workstation used on the restoration scaffolding of the vault and of *The Last Judgement* was a DN3000, equipped with a Motorola 68020 CPU with a 4 Mb RAM memory (that is to say not even half capacity compared to the computer currently used) and a 330 Mb hard disk, with a backup unit using 60 Mb cartridges for data protection and recovery.

The Apollo operating system was an Aegis II, a Unix-like system (therefore similar to Unix both in the control keys and internal functions), developed in Berkeley, CA (USA) in 1983 and made available for sale prior to Unix, the "standard" operating system for high performance workstations.

Apollo's screen is very significant: the operating system displays typical windows (just like Unix), it is able to carry out multi-tasking jobs, and has a computing power of 1.2 MIPS (million instructions per second).

Technical description of the software

The software used for the Michelangelo documentation was a CAD-based suite, developed by Auto-Trol Technologies of Denver, CO (USA) – called Series 5000.

The menu of the basic software enabled the following operations to be carried out by means of a mouse or pen (the latter connected to a graphic tablet):

- view the whole stored image;
- view an image detail;
- zoom in or out on the image;
- recover the original image;
- create a reference grid on the image;
- mark a line;
- mark a perpendicular line on an existing segment;
- mark a parallel line on an existing segment; and
- position a point or a line on the same horizontal or vertical line at a given point.

The basic software was particularly appropriate for implementing engineering and architectural drawings. It consisted of general-purpose software with graphics capability similar to the better-known AutoCAD, but in 1986 certainly more advanced than the AutoDesk product.

As already noted, the software was specifically developed for the documentation of the Sistine Chapel restoration. The customization, implemented in Fortran, allowed use of a special menu with the aid of a graphic tablet. This will be discussed below.

The photogrammetric survey provided curved outlines of the painted representation,

Figure 4. View of the irregular curvature of the vault of the Sistine Chapel.

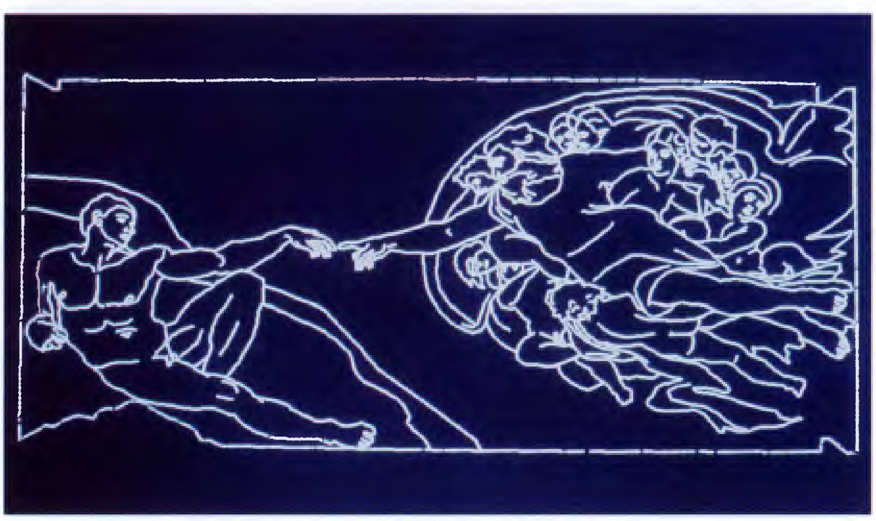

Figure 5. 2-D base map of the *Creation of Adam.*

Figure 6. Superimposition of the fragment of Michelangelo's cartoon representing Amman's head, housed at the Teylers Museum in Harleem, the Netherlands, onto the 1:1 base map drawing of the same area.Figure 3. Graphic documentation carried out by hand on site with acetate sheets placed on top of base map.

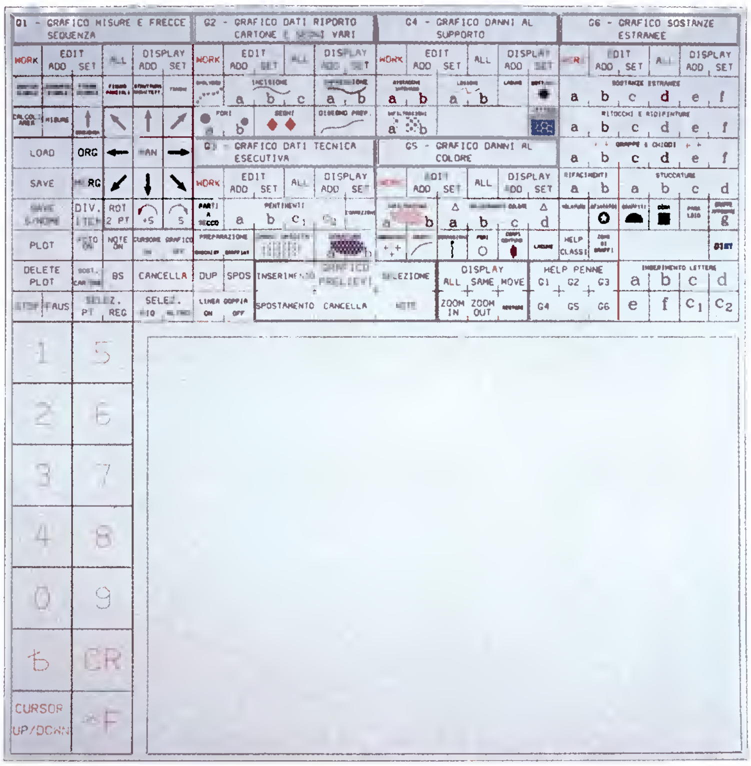

Figure 7. Customized Menu from the graphic tablet, with control functions, symbols, patterns and colours used.

which, as 3-D images, reproduced the true curvature of the Sistine Chapel's vault (Figure 4).

In order to obtain 2-D graphic representations (Figure 5), it was decided to project these photogrammetric line drawings onto a plane. This was also necessary to enable measurement of the frescoes directly from the computer, and to apply with greater precision the graphic symbols (also 2-D) used for the various phenomena recorded. The result was a 2-D base map, consisting of a line drawing that proved to correspond very closely to Michelangelo's lost preparatory drawings, the so-called "cartoons."

The 3-D to 2-D projection began with the data obtained from the photogrammetric survey initially carried out on the frescoes, originally only with the objective of analysing and recording the structural condition of the chapel vault. The 3-D data, representing the main outlines of the painting scheme, together with analogue data relating to the contour lines of the vault's structure, was used as if it were geometrically equivalent to a transparent film fitting precisely onto the surface of the vault.

A special mathematical algorithm, developed specifically for this project, gave the possibility of developing on a plane all the outlines of the painting, maintaining the real dimensions of each figure.

This operation, which seemed quite simple in the vault, because its surface was similar to a cylinder in shape, became complex in the various intermediate areas between larger expanses, as it became quite evident that these surfaces were far from geometrically regular.

The work was therefore performed by analysing *in situ* the 3-D coordinates of the outlines of the figures, reproducing the single segments forming the boundary on the nearest plane to the fresco's tangent plane found in the neighbourhood of the segment being analysed, or by the immediately contiguous segments, or by the contour line segments located in the neighbourhood under consideration.

In other words, starting from a basically flat area, the segments close to each other but not part of the plane, were projected onto the plane, maintaining their linear measurements and changing only the corners of the contiguous segments existing on the initial plane and on nearby ones. In this way the whole length of the figures' boundary was maintained, obtaining an excellent correspondence between the measurements on the plane and the real ones in space. The success of the operation was essentially due to the high concentration of points (derived from the photogrammetry) by means of which the fresco's surface was determined and reproduced in the first model[1]. (Figure 6)

Even though the figures were distorted, especially in areas that were mainly spherical, it was possible to perfectly position the data acquired during the restoration by faithfully maintaining the comparative and total distances. This operation also allowed calculation for surface areas not originally flat or with poor definition.

Data acquisition procedures

The keyboard was rarely if ever used, as it was possible to work exclusively with a pen and the tablet, the reason being that the customization incorporated the following control functions:

- LOAD: loads a drawing from the file;
- SAVE: stores the modified drawing;
- SAVE/SN: automatically stores the modified file under the same name;
- PLOT: prints drawing onto paper;
- DEL PLOT: interrupts the plotting procedure;
- CANCEL: cancels one or more graphic symbols already stored;
- BACKSPACE (BS): cancels the last graphic symbol stored;
- DUP: duplicates a graphic symbol;
- SPOS: moves a graphic symbol from one point to another;
- DOUBLE LINE SPACING ON/OFF: modifies the width of a line;
- SELECT POINT/REGION: allows selection of one or more symbols or lines to be modified (level, class, colour, typology);
- GC ON/OFF: activates/disactivates the graphic cursor on the screen;
- PAUS: temporarily interrupts the graphic program;
- STOP: closes the graphic program definitely;
- HELP "CLASSI": displays the numerical attributes belonging to the graphic symbols.

These numerical attributes enable detection and to logically distinguish one symbol from another. The software, Series 5000, allows 250 different symbols to be handled, whether they are points, lines or more complex symbols.

These control functions, which can be accessed with the pen directly from the graphic tablet, considerably simplified access and use of the customized graphics software (Figure 7).

The customization enabled storage and handling of the following types of information:

Techniques of execution

- Graphic documentation of the artist's *giornata* arranged in order of sequence;
- Graphic documentation of data relating to the use of cartoons, other transfer techniques, preparatory drawing:
  - indirect incision;
  - direct incision;
  - direct incision using a ruler, wire or twine, or callipers;
  - pouncing;
  - cord snapping;
  - roller marks (*impressione di "rotelle"*);
  - nail holes used to fix cartoon;
  - nail holes used to anchor wire, twine or roller;
  - nail holes used to set up architectural scheme;
  - imprints of maulstick, of fingers or finger nails;
  - traces of the preparatory sketch.
- Graphic documentation of other data relating to the techniques of execution:
  - secco parts;
  - *pentimento* done in fresco technique;
  - *pentimento* done in *secco* technique (using lime);
  - *pentimento* done in *secco* techniques (using glue);
  - small corrections carried out by using the fresco technique during the work in progress;
  - preparation of the *pentimento* by scraping;
  - preparation of the *pentimento* by scratching;
  - small-scale original infills of damage caused by humidity;
  - gold leaf applied with an adhesive

State of Conservation

- Graphic documentation of damage to the support:
  - lack of adhesion of rough plaster

(*arriccio*);
- lack of adhesion of fine plaster (*intonaco*);
- damage in the wall structure;
- cracks in the plaster;
- missing fragments of fresco;
- infiltration of rainwater (erosions);
- infiltration of rainwater (dark spots);
- *bottaccioli* (i.e. expanding unslaked lime lumps);
- previous consolidation intervention (presence of brick flakes);
- previous consolidation interventions (presence of various types of metal clamps to anchor plaster).

• Graphic documentation of damage to painted surface:
- infiltration of rainwater (corrosion due to soluble salts);
- infiltration of rainwater (deterioration due to silicate);
- lack of adhesion of the paint layer;
- abrasions;
- extended scratched areas;
- occasional scratches;
- damage resulting from blunt instruments;
- corrosion;
- holes from previous consolidation injections;
- loss of paint.

• Graphic documentation of foreign substances:
- dust;
- soot;
- glue;
- retouching and repainting (with different methods);
- plastering;
- repair in fresco;
- secco repair;
- colour glaze (*velature*);
- vents;
- graffiti;
- wax and sealing wax.

• Graphic documentation of samples taken for chemical analysis: Even the points on the fresco where the paint samples were taken for chemical and stratigraphic analyses were entered into the computer. In these cases, the graphic image also had associated alphanumeric data.
Entering such points allowed:
- positioning the sampling site accurately on the relevant area;
- serial numbering of all samples;
- dating each sample;
- indicating the type of analysis required (chemical or stratigraphic); and
- obtaining information about queries.

The customized menu enabled the user to select, move, cancel and modify previously stored samples.

Censorial draping
The mapping of the censorial draping decreed by the Council of Trent to cover *The Last Judgement*'s nude figures was registered and divided into groups, according to the technique of execution (*secco* or fresco) and to the chemical and stratigraphic results obtained from analysis of the paint samples.

Cleaning tests on *The Last Judgement*
A map relating to the cleaning tests was made, using different colours for the various cleaning methods.

INNOVATIVE FEATURES
Some innovative features of the software customization are considered below, consisting of functions directly activated with the graphic tablet.

"FOTO" ON/OFF.
Photographs of the restoration were normally taken in the form of 6x7 cm colour transparencies and black and white negatives. This function of the special graphic software automatically produced a proportional adaptation of the actual size of the portion of the fresco that was to be photographed. A precise map of the identical photographs to be taken before, during and after the restoration could be provided and delivered to the photographer in charge.

NOTE ON/OFF
The mapping layer could incorporate information, displaying it upon request.

MEASUREMENTS
Surface measurements and actual distances in the vault and *The Last Judgement* were calculated by means of a particular function that provided:
- variable precision (centimetres or millimetres) of measurements;

– display of the measurements in a graphic form on the drawing;
– automatic storage of the measurements calculated and comparison with other measurements of scenes or similar details.

MERGE
One or more mapping layers relating to the same subject were automatically overlapped, to compare the different types of information acquired for that scene or for a detail of it. In this context, it should be stressed that each item was recorded on a separate layer and saved as a separate file.

DL CARTOON
This function suppressed the base map (the improperly called "cartoon" as the one used by Michelangelo to transfer the drawing onto the fresco) on screen, leaving only data on the display.

CAPTION
This displays a legend of the information relating to a drawing. As soon as this function is activated, special masks automatically appear as a footnote, consisting of the symbols used and their meaning. This function is very useful when printing the various scenes on paper.

PRINTING ON PAPER
The PLOT control function was also customized for easier use and to better suit documentation requirements. During editing, up to eight different colours may be used, and any of the following could be selected:
– subject to be printed;
– subject rotation for plotting purposes;
– caption;
– standard printing format (A0, A3, A4); and
– drawing scale.

The data gathered by the author in nearly eight years of work on the restoration scaffoldings certainly represents the most complete and precise collection of technical documentation that has ever existed for a work of art and its state of conservation.

Approximately 2 Gb of data were accumulated, copied onto 30 back-up cartridges, and stored at the Art Restoration Laboratory of the Vatican Museums.

In 1996, a DXF format translation of all the data was performed to obtain compatibility with AutoCAD current release.

All the significant information acquired was published as two reports: *Report on the Restoration of the Vault* and *Report on the Restoration of The Last Judgement*, published in Italy by the Istituto Geografico De Agostini, Novara, in 1994 and 1999 respectively.

For the author, this experience was unique and certainly unrepeatable, as it provided the opportunity to put into practice a completely new method of acquiring documentation, not only from a technical point of view but also qualitative, which up to now has never had the respect it deserves, considering the importance of such documentation for every conservation project.

Finally. the author would like to publicly thank all of those who believed in the methods described above during the years of the restoration of Michelangelo's frescoes and who gave their unconditional support – support that was so vital in carrying out, in an absolutely individual but still serene dimension, such a delicate and impressive assignment.

In particular, the late Professor Carlo Pietrangeli, former Director General of the Vatican Museums; Dr Walter Persegati, former Secretary and Treasurer of the Vatican Museums; the Restorer in charge, Dr Gianluigi Colalucci, former Chief Restorer of the Art Restoration Laboratory and currently Restoration Consultant for the Vatican Museums; and finally the late Fabrizio Mancinelli, who, as already noted, was Director of the Restoration Works and a model for his sense of discipline and humanity, to whose memory the author wishes to dedicate this contribution.

ACKNOWLEDGEMENTS
The author wishes to thank the *Direzione Generale* of the Vatican Museums, and particularly Dr Francesco Buranelli, Acting Director General, and Dr Edith Cicerchia, Secretary, for giving this special opportunity.

18

GRAPHIC INFORMATION SYSTEMS FOR THE CARE AND MONITORING OF MONUMENTS: A REPORT ON AN EXEMPLARY DATA ACQUISITION, VISUALIZATION AND ANALYSIS SYSTEM USED FOR THE DOCUMENTATION OF MEDIEVAL WALL PAINTINGS

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ABSTRACT

Technologies such as image processing, multispectral analysis, video graphics, computer aided design (CAD) and database techniques, together with mathematical and statistical techniques such as cluster and factor analysis, have furthered the development of conservation documentation techniques and methods for mediaeval wall paintings.
A clearly scheduled interactive process should be facilitated. The development of data processing enables the creation of effective links between different sources of information, such as maps, textual information and photographs. This in turn leads to improvements in time saving and the chance to carry out high-quality treatment. Within the framework of various computerized research projects in Lower Saxony, Germany, there is the basis for the setting up of a multidimensional, image-based computerized information system. With this system, the different sources of information should enable scientists to specify the potential for damage to all existing wall paintings in Lower Saxony.
KEYWORDS: data-photo processing; mapping; multispectral analysis; CAD; cluster and factor analysis; damage chart; computerized information system; ICONCLASS.

THE DATABASE OF MEDIEVAL WALL PAINTINGS IN LOWER SAXONY – SERVICE POSSIBILITIES FOR THE CARE OF MONUMENTS AND CULTURAL SCIENCE

Historic wall and ceiling paintings are important evidence of our cultural heritage. The decorated painting of rooms has been an essential part of interior design in different cultures and epochs. Through illustration, they can convey cultural values and norms. As eloquent witnesses of their time of execution, they reflect cultural developments and provide information about changes or continuity in customs, morals, religion, world view, art perception and taste over time. Moreover, a chronological history of craftsmanship and technology can be demonstrated.

From the Middle Ages alone, Lower Saxony, Germany, has a stock of more than 250 important painted interiors. In recent years, it has been possible, within the framework of an area-specific computer-aided inventory, to document and evaluate this stock according to diffusion and age, principal damage and art-historical content (Grote, Glashoff, and Pandlowsky, 1994, 1996; Dobrat and Paelke, 1989; Anon., 1990b; Seiberlich, 1991). A future advancement of this inventory project will be a corpus with a corresponding graphic documentation catalogue relating to the condition of the works (Schladenhaufen 1991; Grote, 1991).

In order to quickly obtain first results, a reduced version of a practice-orientated database, containing basic information, was developed cooperatively between documentation specialists and heritage managers (Hilpüsch, 1995). It can be iteratively extended and contains the following elements:

- Data referring to buildings (owner, contact person, heating, material, damage to building, etc.).
- Abbreviated description of the iconographic context (evaluation of the representations according to the art-historical classification system ICONCLASS of the Dutch Academy of Sciences (Van de Waal, 1981)).
- Location of the individual paintings within the building, with graphic orientation through reference maps.
- Stock-taking and condition recording of the wall paintings by the restorer (indications on painting technique, previous restoration, decay, etc.).
- Documentation photographs as a visual aid.
- Literature quotations according to international standards, with annotations of statements relevant to the building and the paintings.

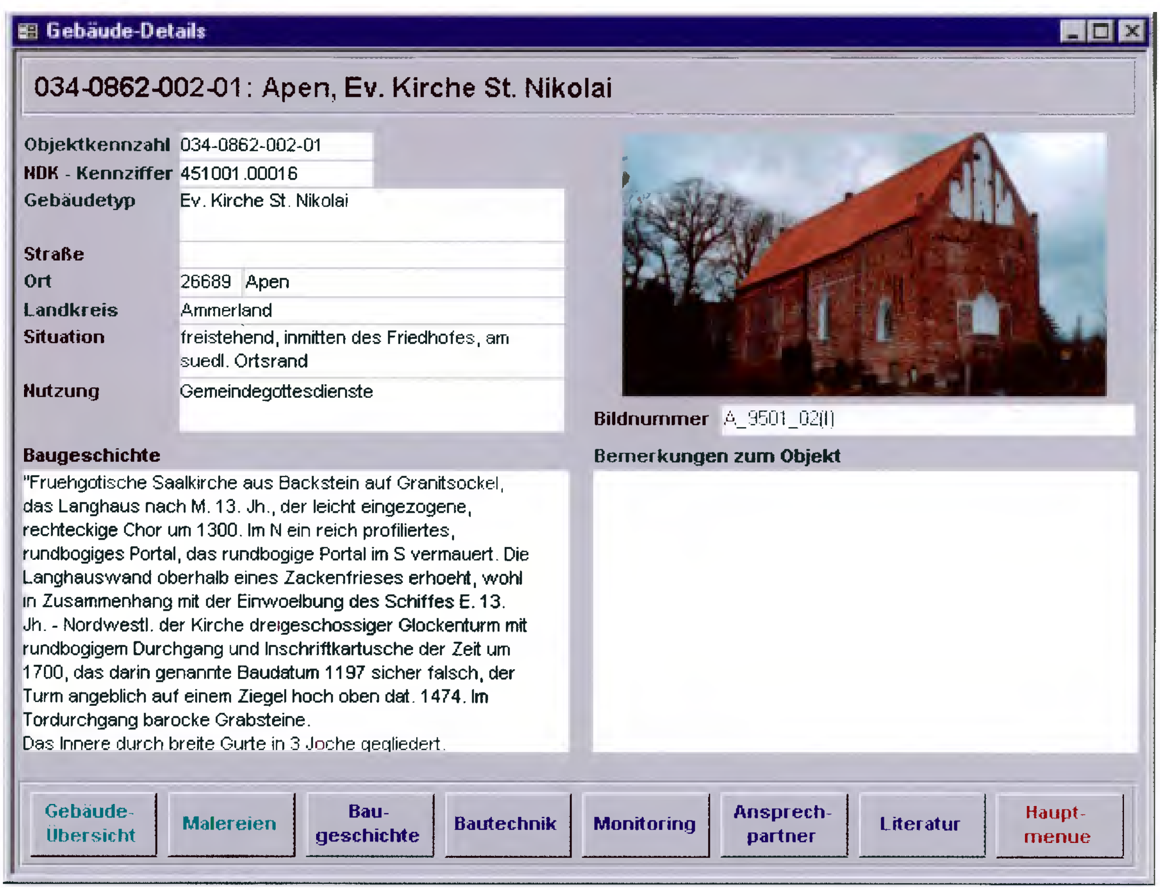

Figure 1. Data bank "wall paintings," Apen, protestant church, survey/chart of buildings.

Through a search module, it is possible to answer a variety of queries for daily cultural heritage management (Papendorf and Grote, 1997). Possible search questions out of the wide range of art-historical and management queries could include:

- In which cultural monument in the district of *Hildesheim* do mediaeval wall paintings exist?
- Which Lower Saxony wall paintings from the 14th century depict the birth of Christ?
- Which wall paintings in the *Braunschweiger Dome* show damage due to algae growth or salt crystallization?

Once the potential for development has been fully exploited, a whole host of problems deriving from the care of monuments can potentially be solved. For a global conservation management plan, this would include the possibility of creating an object-orientated monitoring system for maintenance and quality management, or – considering the stock of Lower Saxony wall paintings as a whole – a damage catalogue based on graphic documentation, covering the entire territory.

COMPUTER-AIDED MONUMENT INFORMATION SYSTEMS FOR HISTORICAL WALL PAINTINGS

Problem definition

Because resources are becoming increasingly scarce, personnel and funds must be put to use more efficiently, including in the care of individual monuments, without the quality of service and work performance suffering. How this aim can be achieved, and what positive possibilities for solutions already exist, can be demonstrated by wall paintings, as an especially problematic art form (Anon., 1985, 1990c, 1994b, 1996).

Cultural assets preserved in interiors (Fitz, 1985; Fitz *et al.*, 1984; Camuffo and Bernardi, 1988, 1991; Fuchs and Leissner, 1992), such as historical wall paintings, are threatened by innumerable decay factors. In order to record, interpret and quantify these complex mechanisms and

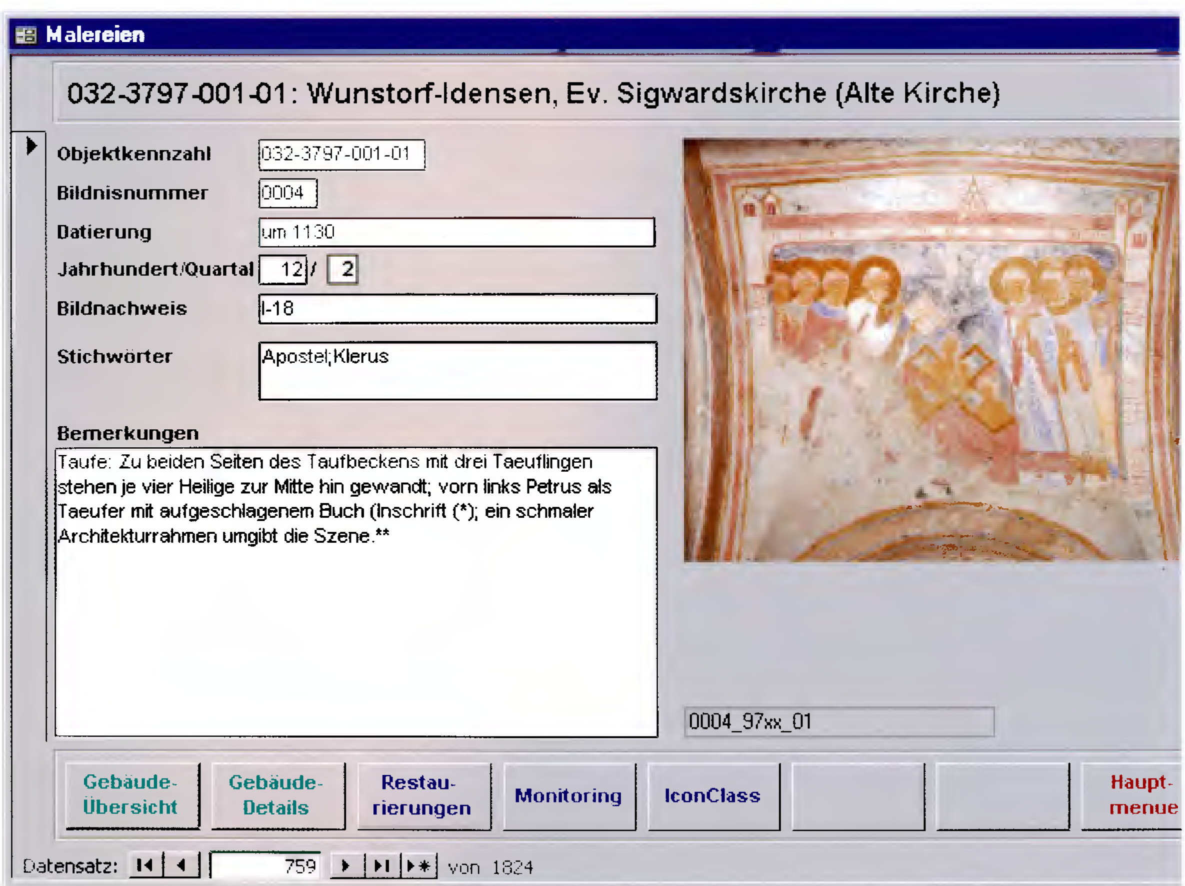

Figure 2. Data bank "wall paintings," Wunstdorf-Idensen, file "paintings".

their effects, and to establish treatment and maintenance protocols, a methodically sound working and documentation system is urgently required (with "documentation" taken to mean the "planned collection, ordering and utilization of documents and data" (Glashoff, 1989)). As traditional methods of information management for the processing of complex queries have evidently reached their limits, computer-aided working tools have received increasing emphasis internationally (Anon., 1992, 1994a, 1994c; NLD, 1993; Casciu, Centauro and Cimenti, 1996; Centauro and Maffioli, 1989; Beck, Temme and Rademacher, 1996; Grote, 1996; Gutscher and Favre-Bulle, 1996.).

The care of cultural heritage shows parallels to the field of medicine: therapy in both cases depends decisively on a careful case history and diagnosis – irreparable long-term damage is the consequence of actions that were initiated and carried out unsatisfactorily.

Historical wall paintings are complicated, compound systems. Thus, as a rule, the design and the implementation of a systematic chain of actions aiming at their care is extremely difficult. The specific damage potential to an individual cultural monument as well as its context and its environmental influences must all be considered. During this process a very heterogeneous quantity of information has to be recorded, evaluated and correlated, and – following interpretation – transformed into a therapy concept (Grote, Stelzer and Weinzierl, 1991, 1992; Grote and Stelzer, 1992; Glashoff, 1994; Grote, 1994).
The most important information media are:

- visual information: photographs, survey plans, graphic records, etc., and
- textual information relating to the building, to the wall paintings, to graphic records and data concerning scientific analyses.

The main difficulty is that a lot of such information items must be linked and related to each other. This results in a huge quantity of possible interactions that can really only be managed and evaluated in a computerized or mathematical-statistical way (e.g. through cluster or factor analysis (Glashoff, 1992)), involving:

- interaction of data elements referring to 3-dimensional space (correlation between wall paintings and the room);
- exact attribution of the information elements to the time component: single working steps must be comparable – especially in relation to earlier measures – in a multi-temporal time continuum. This is because the care of wall paintings is a never-ending process. The most important phases of this process (case history, diagnosis, therapy, monitoring and quality control) lead eventually to new preservation measures if primary sources of damage were not properly identified and eliminated;
- standardization, in order to guarantee the comparability of the data. All documentation has, therefore, to be developed in the same manner (i.e. according to an established standard);
- and, finally, the interdependence of the damage phenomena themselves and their dynamic processes have to be recorded and connected meaningfully as a basis for the creation of therapy concepts.

Possible solutions
Rapidly evolving innovative techniques and methods, such as image processing, multispectral imaging, computer-aided design (CAD) and computer-aided data administration, offer meaningful applications for many aspects of heritage management. The use of data processing provides a major opportunity to effectively link different types of data sources, such as graphic records, textual data and images, measurements and analytical data, in order to obtain urgently needed improvements in terms of time planning and quality of treatment of cultural heritage.

During various projects (Anon., 1990c, 1992, 1994a, 1994b 1994c; NLD, 1993; Casciu, Centauro and Cimenti, 1996; Centauro and Maffioli, 1989; Beck, Temme and Rademacher, 1996; Grote, 1996; Gutscher and Favre-Bulle, 1996; Grote and Königfeld, 1995; Beck and Temme 1996; Pandlowsky, 1996.), the basis for an image-based, computer-aided monument information system has been developed at the Regional Office for the Care of Monuments of Lower Saxony (NLD) in co-operation with the German Mining Museum. At the same time, a wide variety of experiences and suggestions for improvement have been collected through field applications.

Research project "Damage to wall paintings"

In the course of the research project *Damage to wall paintings*, financed by the Federal Ministry for Research and Technology, an innovative work and documentation system was developed (and has since been considerably refined and improved in practice since 1991 (VDI, 1987; Mirwald, 1989; Glashoff, 1989; Beck, Geruschkat and Glasshoff, 1990; Glashoff, 1994)). Its aim was the development of an integrated modular Monument Information System that could be adapted flexibly to each object with its specific problems.

The development of the project was characterized by the need to manage an overabundance of heterogeneous data. This issue appeared, for example, even in 'usual' conservation or scientific investigation mapping of phenomena (Concerning especially mapping and other visual supports, see: Fitzner and Kownatzki, 1989, 1990; Anon., 1990a; Reichwald, 1985; Drescher and Jensen, 1994; Autenrieth and Turek, 1990; Beck, 1992, 1994; Geruschkat and Glashoff, 1990; Trapp, 1994; Gadesmann and Königfeld, 1996. The actual stage of development reflects Heckes, Hornschuch and Haferland, 1996.), though this "mapping" process is to be understood only as a component of the more comprehensive monument-related database.

In complex decay areas, the traditional methods of condition recording did not guarantee the intended readability. Because of the proliferating amount of data, computer-aided methods became increasingly imperative. The Monument Information System was successfully pilot-tested on specifically chosen objects or object areas. Applicational optimization could not, however, follow because the research project had come to an end in the meantime.

Because many observations, examinations and surveys have to be carried out in the process of the preservation of monuments, the introduction of a three-dimensional coordinate system connected to a database is useful. The exact relation of the variety of interdisciplinary activities to spatial coordinates creates a sound basis for further analysis, documentation and archiving.

The survey of the built heritage was carried out three-dimensionally using tachometry. Reference points that described the building and its geometry were recorded on metric photographs. In a second step, the evaluation of geometric data was improved through photogrammetry. Longitudinal and cross-sections, as well as 3-D grid models, were produced with CAD software.

Conventional photographs served as a basis for the manual mapping of the condition and damage. In the case of wall paintings, it was very important that these individual pictures recorded coherent painting areas. The photographs were, if possible, taken parallel to the wall in order to minimize distortion. Through the overlapping of individual photographs, a photo mosaic was manually created. In this way, it was possible to represent all areas of the monument without any lacunae.

After this, the coordinates of every single picture were taken and correlated to the 3-D room coordinates. Through photogrammetric stereophotographs, the corners and centres of individual photographs could be defined in three dimensions. The tacheometrically surveyed points served, within this process, as fixed points for the photogrammetry, allowing exact orientation of each photograph.

Different mapping methods were tested for condition recording. First, digitally prepared videos were produced and appeared as individual image frames on a laptop computer screen. Appropriate software should allow the mapping of phenomena directly in front of the wall paintings onto the video image appearing on the laptop screen. At the time of the project (1988-1991), because of the technical limitations of the laptops available, the realization of this technology had to be postponed.

As an alternative solution, an attempt was made to develop an independent mapping programme that was based on rectified, analogue rather than digital, photographs. The direct connection, however, between base map and mapping layer was missing: the photo sits separately in a digitizer, while the mapping appears, isolated and without a reference image, on the screen. A further disadvantage lies in the high development costs for special menu-controlled mapping software that could also be used by an inexperienced computer user.

Thus, it seemed wiser to use standard CAD software that met the specific demands and was already available on the market. A single, approximately orthogonal, rectified photo lying on the digitizer was used as a base map. As an aid to orientation, line drawings of the photographs concerned were produced and slotted onto the screen in order to allow localization of the mapping phenomena. The flexibility of this method proved to be a big advantage: the mapping could either be made traditionally *in situ*, to be further processed, or directly entered into the laptop on site.

The collected image data were filed and managed through an interface in a relational database. The database correlated the entry of condition and the textual descriptions so that they could be linked with each other through the system of coordinates. Photographs, video recordings, etc., could be easily assigned to these entries through the database. This also made possible fast location of all stored documents, reproduction of the information at any time, and facilitated communication with other project participants. It also provided a long-term, unified and safe archive of the information. The photo information could be reproduced on the screen for any additional findings and at any later point in time. This permits long-term condition control or monitoring to be carried out in the future.

Photographic and visual recording in the Altenkamp manor house

Problem definition and selection of working techniques

Because of the great art- and cultural-historical importance of the wall paintings, further innovative solutions were tested: *Königslutter* Collegiate Church (Heckes, Hornschuch and Haferland, 1996); *Altenkamp* manor house (with thanks to Mr. Maro Moskopp, Luftbild Eifel, for multiple technical advice). These approaches, in addition to conventional methods of condition recording and documentation, allowed the acquisition of reliable knowledge and assisted in decision-making. The main stress, therefore, was on the use of image data processing using multispectral recording and analysing techniques.

Introduction

"Our so busy century seldom has time to read, but always time to see." (Theophile Gautier, 1858). Possibly influenced by this insight, the technology-driven 20th century has produced numerous "visual aids" in the form of photographic reproduction techniques. A selection of these techniques, attuned to the possibilities of digital data processing, has led in several scientific fields to a situation where computers can see well enough to be able to provide man with readable answers to specific questions.

For example, one can mention the geosciences, which have, for a long time, used multispectral image data from satellite systems for the detection, observation and mapping of territories (ASM, 1983). Especially developed image processing algorithms can produce, through suitable combinations of the input channels, new images that can be easily interpreted by experts (Kappas, 1994). For wall paintings, these methods were tried in *Altenkamp* manor house, in addition to conventional documentation.

Expanded photographic documentation

First, all the wall paintings were photographed using a medium-format camera and black and white film in order to produce the base maps for graphic recording. Additional photogrammetric measured drawings and a number of geodetically defined measuring points represented the geometrical basis for the production of scaled digital base maps (Heckes, Hornschuch and Haferland, 1996).

With the aim of producing a colour-controlled record, the wall paintings were documented using RGB (red, green, blue) colour separations. These were generated by absorption filters where only the spectral part of the respective colour can pass. The colour separations were exposed sequentially on black and white film. The combination of the three channels produces a measurable colour image of the wall paintings. In contrast to conventional colour photography, this method is a more reliable way of colour recording. The major advantage of this method lies in the fact that uncontrolled colour mixture effects, which are unavoidable with conventional colour illustration, can be excluded almost totally (Marchesi, 1998).

To control and calibrate the system, a colour chart with several spectrally measured patterns was included in every photograph.

In addition, in selected test areas showing typical decay patterns, intermediate channels in visible areas of the spectrum (cyan and orange) and in the adjoining non-visible areas (ultraviolet and infra-red) were used to allow a broader differentiation of the spectral properties of the wall painting. These additional channels were a valuable and indispensable contribution to the identification of extremely small spectral differences, that otherwise appeared to be the same colour. Multi-temporal photographs, taken in a comparable standardized process, could, for example, make faded or re-touched colours much more visible.

Digital documentation

As a basis for computer-aided recording, the photographic films were digitized using a controlled scan process. The scan resolution selected was sufficiently fine to allow areas of 1 mm^2 to be clearly reproduced. To achieve a uniform reference system, the images of one spectral channel were rectified and mosaicked, creating an image map. The remaining channels were transformed into this map pixel by pixel.

At the same time, this image map provided the basis for manual mapping. To produce base maps, details were printed in a fixed scale (1:10) on photographic paper. The mapping process was subsequently digitized with a suitable CAD programme structured geometrically by applying standard rules of thematic cartography (Bill and Fritsch, 1994).

Figure 3. Collegiate church Königslutter, external view of the northern transept.

It was possible to define groups of information layers corresponding to the different overlays used for mapping and in addition to the basic information layer on 'painting', four layer groups were added: 'former interventions,' 'damage to the paint layer,' 'damage to the plaster' and 'water damage'.

All the outlines of the visually interpreted phenomena were mapped as closed polygons. The visual differentiation of clearly limited and unlimited areas was carried out by using different line types. The different phenomena could be marked by various types of hatching. The digital information system administered the different areas through a specific numeric identification. In response to database queries it could carry out numerical and statistical analyses concerning damage potential. For an integrated assessment of the monument the data could also be processed three-dimensionally.

In addition to the transfer of manual mapping results to the computer, the possibility of an almost totally computerized recording process was tested.

Summary of results after the completion of the interdisciplinary work

- The multispectral photographic technique provided a good visualization of existing decay patterns. Most of the mapped decay phenomena could be located on the photographs. Various types of damage, especially physical damage such as cracks, spallings and mechanical defects, could be identified and located more simply, more precisely and more quickly directly on the multispectral images than could be done manually on site.
- Because of the individual knowledge and skill of the operator, mapping by hand can only give a first overall view of damage. The image processing techniques, with fixed, calibrated and verified rules, could provide a more objective method to support the interpretation and monitoring of phenomena.
- According to current technical standards, archiving the digital records, per-

manently and in a space-saving manner was possible. Access to and the reproducibility of the results remained constantly ensured.

- Within the framework of a long-term maintenance programme, with the expectation of further targeted development, it would be feasible to prepare graphic records that did not show the signature of the various experts involved.

Computer-aided automated documentation

As a long-term objective for multispectral data recording and evaluation, an attempt was made at recognizing a typical damaged picture using automatic image analysis. The images were interpreted as a matrix of tiny picture-elements (pixels), i.e. as a multitude of individual surface areas, which show differing light reflectance due to their different physical properties. By dividing the spectrum of light into several parts and by measuring the reflectance in each of these parts, several information attributes for each pixel can be stored and attributed to an n-dimensional point.

A definition of interpretation keys and their mathematical definition, leading to automatic damage mapping, will only be possible through very close interdisciplinary teamwork.

Figure 4. Collegiate church Königslutter, internal view of the northern transept.

The expenditure on recording using multispectral imaging was not inconsiderable, but this development should lead to thematic mapping of phenomena without human involvement. The object information has to be optimized, in relevant spectral areas, and the technical expenditure for the realization of the spectral bands must always stay within reasonable limits. A great advantage of this kind of object documentation through expanded photographic recording already exists today: synergy effects occurring during the digital combination of spectral bands can make damage phenomena clearly more visible.

This means that multispectral analysis could become a method of condition recording capable of, in part, being carried out sitting in the office and could optimize expenditure, such as for scaffolding time. A further advantage is the possibility of direct digital mapping without the need to re-draw in a manual mapping process.

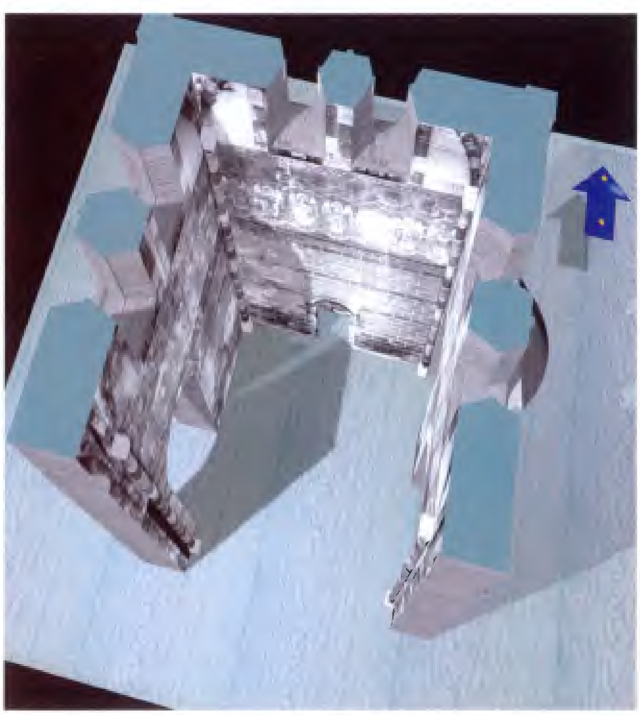

Figure 5. Collegiate church Königslutter, internal view of the northern transept.

RESULTS

The model experiments produced numerous ideas that can, as components of computer-aided methods, already be used in the forefront of important restoration projects. It has been emphatically shown in all projects of the NLD that a general survey of the site and of all the relevant, mostly very heterogeneous, damage factors is imperative in order to structure the considerable personal, logistic and financial constraints, before any scientifically substantiated examination is possible (integrated object recording). Bringing in an interdisciplinary research team is sensible only after such an extended preparatory phase.

So far, the following major working phases have been applied in practice:

- Complete geometric and colour true images of the wall paintings and their damage as a basis for interdisciplinary condition mapping by hand, and also as a basis for further computer-aided processing for the creation of a corresponding Monument Information System (database).
- The Monument Information System has a modular structure: it can store and process geometric information, images and text, needed for both the condition recording and further processing steps. The input and retrieval of data occurs on a computer by using information layers that are filed through a window technique in a relational database.
- The mapping of damage characteristics of an object is not carried out by hand as it has been so far (for example, with coloured pens on transparent sheets over a photograph) but directly on the computer, where any section of the wall painting can be visualized on the screen, providing the base map. On top of this base map and directly on the screen, specific painting contents can be recorded and interpreted by using appropriate software. The recorded damage characteristics should be filed under a legend and a specially created menu, and then stored as layers. In this way, various damage characteristics can be easily correlated. This will assist interdisciplinary research into the causes of decay. Apart from this, the computer-aided recorded mapping data can be related using spatial coordinates to a 3-D-model and stored in a database, from which it is quickly retrievable.
- At present, the methods developed for condition recording and documentation have a modular structure, with interchangeable components. These methods can be extended into an integrated system of object recording, in order to be able to carry out, during a rough examination, a first general analysis of the object, including all the very heterogeneous characteristics and damage factors that have had an impact. In addition to this, further modules for the spatial distribution of parameters such as dampness, salts, temperature (thermography, electro-resistance and capacity measurements, electromagnetic reflection (EMR), radar and seismic methods, and so on) should be employed in order to identify active and inactive zones.
- Using the potential of further research, the most important parameters of the recorded data are transferred into a simplified 3-D information model. Thus it is possible to detect damage areas in terms of their spatial relationship. Also it is possible to correlate 'old damage' (information from old files, archived records, old photographs, etc.) with the current findings. The 3-D model can give a detailed view of all information belonging to an object, especially for complex buildings where the information can be attributed to different rooms.
- After a preliminary recording of damage (phenomena mapping), analytical-statistical interpretation aids (factor and cluster analysis (Glashoff, 1992)) should be used to support research into the mechanisms of decay. With these methods it should be possible to distinguish between dominating and accidental symptoms in potential decay areas and thereby assist in development of correct intervention strategies. Apart from this, they should reduce observations and analysis to the necessary minimum. Thus it would allow better control of analytical expenditure on site, and yet provide indications of the causes of decay, thus facilitating the design of interpretation aids for interdisciplinary research.

Figure 6. Manor house Altenkamp, side view from the west.

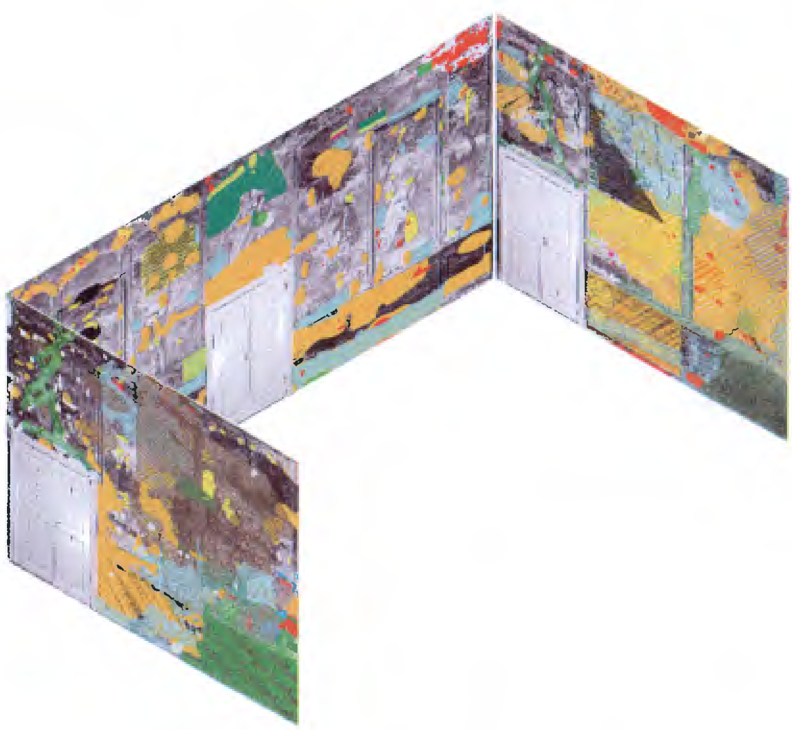

Figure 7. Manor house Altenkamp, three-dimensional visualization of entrance hall, overlaid with mapping of damage, side view from the north-west.

Figure 8. Manor house Altenkamp, entrance hall, detail of wall painting on the south wall, overlay of colour extracts /separations. The colour image was calculated on the basis of black and white spectral images (see illustrations 4 – 6). In this way, a long-term stable, reconstructable, colour-metric image can be realized through calibration of the photographic process.

Figure 9. Manor house Altenkamp, entrance hall, detail of wall painting on the south wall, red separation.

Figure 10. Manor house Altenkamp, entrance hall, detail of wall painting on the south wall, green separation.

Figure 11. Manor house Altenkamp, entrance hall, detail of wall painting on the south wall, blue separation.

Figure 12. Manor house Altenkamp, entrance hall, detail of wall painting on the south wall, UV-fluorescence recording. The image is generated by lighting at 320 – 380 nm and by filtering at 440 - 660 nm. The use of different colours in earlier restorations of the figure on the left becomes clearly visible.

- As a whole, the systematically structured sequence of actions is useful for sound fact-finding operations and thus for effective planning and supervision of operations, including quality control.

SUMMARY

- Together the partly innovative computer-aided NLD methods for case history, preliminary damage diagnosis and documentation form an integrated system, whose components – according to the object-specific requirement profile – are exchangeable or dispensable. However, when dealing with important monuments, emphasis should be given to a complete application.
- Of course, computer-aided methods of visualization and documentation developed or planned within the research projects mentioned above can only provide preliminary aids for interpretation. They are to be seen as a service that facilitates the first steps into a more thorough examination for an interdisciplinary research team, and supplies first indications of conservation and restoration measures.
- In this context, adequate methods of preliminary diagnosis could – in a second phase that concentrates, above all, on object-relevant reference areas – gain in importance.
- In doing this we must always give priority to a fast and precise acquisition of complex data structures, to the possibility of correlating them and developing them into a therapy and maintenance concept, and to storing them long term, in view of multi-temporal reproducibility for quality insuring monitoring measures. At the same time, when possible, the proven manual methods – considering a gradual shift to computer-aided methods – should also be put to use.
- Provision must be made for the necessary ongoing maintenance and updating of these highly developed working tools, requiring properly trained and specialized personnel, including qualified documentalists, with extensive experience in the heritage conservation field.

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Figure 13. Manor house Altenkamp, entrance hall, image map of the south wall, overlaid with thermo image. The thermo image consists of four images. Radiation between 8 and 14 m reflected by the object was registered. The picture shows cold areas on the edges of the walls (connection with exterior walls or non-heated adjoining rooms). The warmer (green) area in the middle indicates that warmth is sucked off through an open fireplace in the adjoining room.

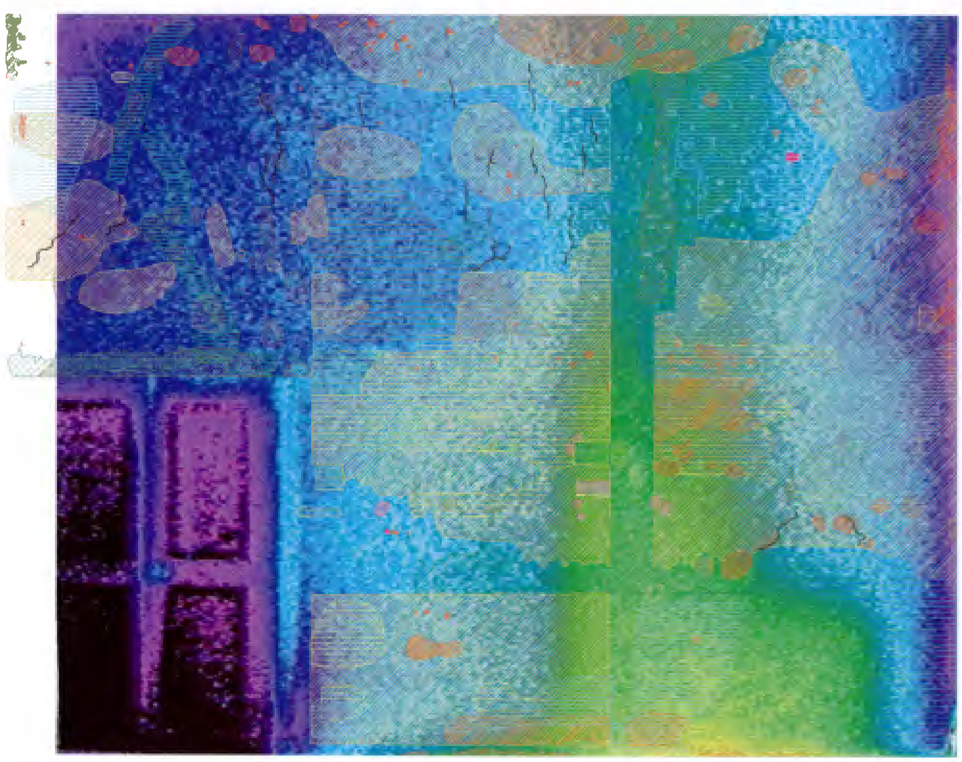

Figure 14. Manor house Altenkamp, entrance hall, thermo image of the south wall, overlaid with mapping of damage. The overlay correlates the mapping of damage with physical information about the building.

Figure 15. Manor house Altenkamp, entrance hall after the restoration.

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THE ARCHIVAL DOCUMENTATION SYSTEM: THE COMPUTERIZED HEART OF THE RESTORED "HISTORY OF THE TRUE CROSS" BY PIERO DELLA FRANCESCA

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ABSTRACT

To follow the complexities of a major project – the conservation of the *History of the True Cross* by Piero della Francesca, in Arezzo, Italy – a special technical group was formed to set up an interrelated archival documentation system. The system included technical, historical and scientific data, as well as photographic images and base maps, cross referenced to provide easy access to all users and support to the conservators.
KEYWORDS*: documentation; archival system; Piero della Francesca; Legend of the True Cross; Arezzo.*

INTRODUCTION

Starting in 1985, the *Piero della Francesca* Project undertook the examination of the pictorial cycle in the Main Chapel (*Cappella Maggiore*) of the Basilica of San Francesco, Arezzo, Italy. The paintings have been dated to between circa 1452 and 1466. In view of the complexity of the task and the distinct areas of expertise needed, the scientific programme was initially divided into various research sectors, covering the environment, structure, pictorial surface, and the history of the monument. The results of these investigations can be found in the publications in the bibliography. The *Piero della Francesca* Project was directed by the local office in Arezzo of the Ministry of Cultural Heritage and Cultural Activities (*Soprintendenza*), with the executive cooperation of the national centre for the conservation of cultural heritage; *Opificio delle Pietre Dure* (OPD), based in Florence. The sole sponsor was the *Banca Popolare dell'Etruria e del Lazio.*

Starting with the preliminary investigations (1985/1990), through to the beginning of the actual restoration, this project benefited from the participation of some of the most important national public and private research bodies (ICR, CNR, universities and others). Restoration proper started in 1991, and at the same time the Archival Documentation System (*Sistema Documentazione Archivio* (SDA)) was set up.

The technical team, known as the SDA Group, included Giuseppe Alberto Centauro, Architect, responsible for the project in general, as well as executive direction; Massimo Chimenti, Architect, in charge of the design and implementation of the database system (until March 1996 in collaboration with Luca Menci, Engineer); and Ginevra Facchinetti Pulazzini, in collaboration with Elena Capua, in charge of archiving and digitizing data. The SDA activity coordinator within the *Soprintendenza* was Dr Stefano Casciu, while Dr Laura Speranza has been responsible for the photographic archives. An essential contribution for the implementation of the restoration came from Silvano Lazzeri, Chief Restoration Technician in the *Soprintendenza*.

It is important to stress that SDA – which was fully sponsored by the *Banca Popolare dell'Etruria e del Lazio* – was planned not only to provide a complete and innovative method for archiving data, but also as an instrument of immediate utility during the conservation work. Such a system emphasises the interdisciplinarity that should be the basis of every scientific conservation intervention. Traditional documentation techniques would have had great difficulty in providing effective correlation in such a direct and understandable way among the many different fields of analysis and research, and at the same time function efficiently as a daily working instrument for the Project.

The SDA concept and implementation has been reported on and published in national and international meetings and seminars (e.g. Casciu and Centauro (1996); Chimenti (1996); Casciu, Centauro and Chimenti (1997); Casciu (1997)) and a popularized version published on the bank's website at http://www.bpel.it.

PAPER ARCHIVES AND THEMATIC CORRELATION

The huge amount of historical, technical and scientific data associated with a complex intervention has always been a problem, one that is not easily solved by traditional methods of archiving texts and images. Right from the outset of this project, it was clearly necessary to organize information in a way that made it readily available to the technical-scientific staff coordinating the work and operating directly on the worksite.

It was evident that a large amount of data, material and documents of various kinds would be produced. To give an idea of the extent of the documents included in the actual data collection, already by the start of the restoration there were 7000 photographic images of various different types (including visible light, UV and IR); hundreds of stratigraphic and chemical analyses of samples; photogrammetric records of the masonry and the pictorial surfaces; and about 2000 thermograph images. The quantity of documents tripled during the restoration intervention, with photographic images alone exceeding 20000 units in total.

In order to organize such an archive that includes text, graphic and photographic data, from the start it was planned to develop a computer-aided information system, based on the following objectives:

- systematic global reorganization according to globally defined criteria and methods of the materials and the documentation collected and produced within the project;
- definition and creation of autonomous archives divided on a thematic basis;
- chronological reading of the interventions; and
- preservation of materials in specifically prepared containers and cabinets.

Considering its heterogeneity and quantity, the traditional archive has been divided into four sectors, according to the scheme that also formed the basis for structuring the computerized system:

- historical archive;
- investigative archive;
- restoration archive; and
- promotional archive (exhibitions, meetings, publishing).

To facilitate navigation, special general maps and linkage charts were developed.

The photographic slides (diapositive transparencies) that constituted the bulk of the documentation were archived according to chronological, iconographic and topographic criteria, and all the images in 24 mm 36 mm format were duplicated onto a digital support (Photo-CD). The images acquired through this method were selected and subdivided for digital management into sections related to the project's thematic sectors.

It was immediately recognized that such an extremely specialized and vast archive could only be adequately managed and rendered useful for the conservation intervention by using an information system specifically developed to record, conserve and manage all the data.

A number of priorities were established during the planning definition stage for this system:

- multiple access facility to image and documentary data to allow rapid consultation;
- realization of thematic maps in layers for correlation and synthesis of the graphic data collected during the preliminary investigation, diagnosis and historical research phase; and
- the database organization should support other activities, in particular for publishing and promotional purposes.

COMPUTER-AIDED MANAGEMENT OF THE ARCHIVE AND THE RESTORATION DOCUMENTS

The idea of a permanent record of the condition of the pictorial surfaces, based on the acquired knowledge, and in support of decision making when faced by the complex problems of the conservation intervention, was thus linked immediately with the idea of a global and multifunctional documentation system, which would not only preserve all the data, but also enable real-time updating of records and make them available to the conservators at work, and provide a firm basis for future controls. Digital processing of data in a system efficiently integrated with the archive resources seemed to be the best response to these needs.

As a result, a system for the acquisition, recording and processing of data in different formats (texts, maps and images) was designed, exploiting the most up-to-date computer technology.

It was considered necessary to facilitate access to the data and to organize them in such a way that they could be easily compared, in order to be able to extract new information from such comparison. The instrument had to be closely integrated with the day-to-day activities, in order to provide a sort of aided restoration *in situ*. Specific requirements of the technico-scientific project staff and of all related activities were taken into account at the design stage of an original system having the final aim of correlating conservation methodologies and procedures with diagnoses and the various ancillary research fields.

The creation of a mapping system specifically developed on the basis of photogrammetry, the formulation of new documentation methods, the integrated use of historical archives, and the creation of advanced data processing instruments are the salient aspects of the SDA system.

In order to be even better adapted to assist in handling problems arising during the work in progress and to become ever more flexible and useful to the operators, the SDA was then updated and modified gradually, following indications of additional desirable capabilities, often indicated by those same technicians. The fine-tuning of the project and its coordination was therefore continuous, requiring the constant presence of the SDA group members alongside the conservator-restorers, to collect and computerize the data and to combine the needs for systematic structuring of the archives with the digital translation of the data and the processing of new items.

The correlation of the results coming from different diagnostic investigations was, in practice, essential to build truly useful and significant operative procedures and consulting systems. This became possible through advanced computer technology giving the possibility to compare data of different origins and thereby obtaining new insights through juxtaposition, superimposition and comparison.

The raster type information is integrated with alphanumeric data in a relational database, linked to the CAD system by specific functions. The database is structured according to a series of categories: descriptive; diagnostic; interventions; and didactic.

The sections defined in the system are:

- Images
- History
- Mineralogical-petrographic analyses
- Chemical and stratigraphic analyses
- Restoration trials
- Intervention
- Restoration
- Workshop diary

Structured search menus for each section help the user in efficiently obtaining the desired information.

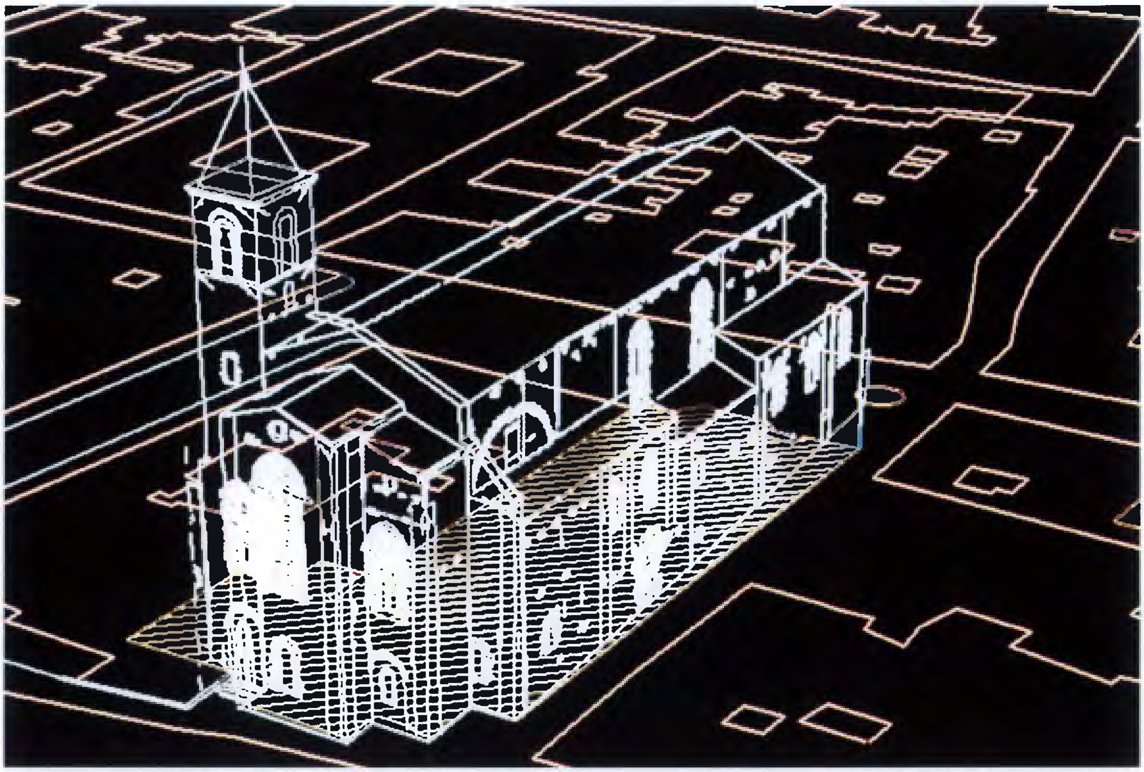

Figure 1. Three-dimensional model of the basilica obtained through a photogrammetric survey. It constitutes the basic geometric support for studies and analyses on the architecture and the frescoed walls.

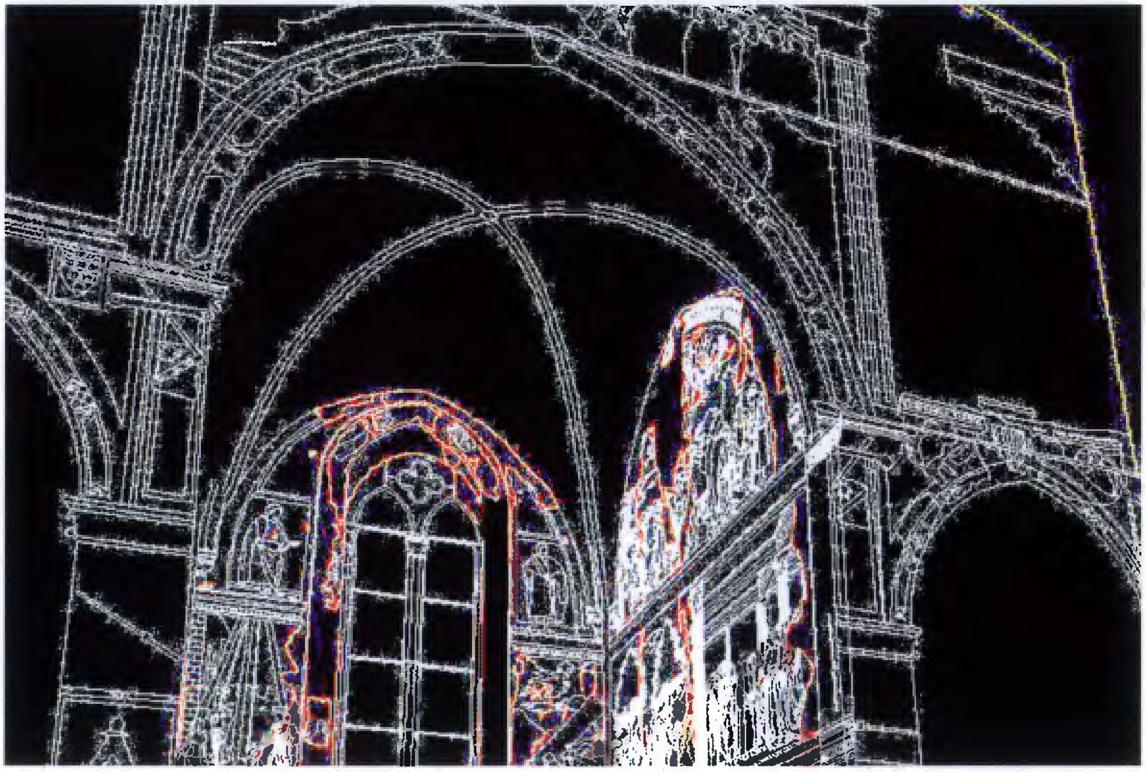

Figure 2. Perspective view of the frescoed chapel. The geometric model allows one to view the survey of all the walls in a single 3-D space.

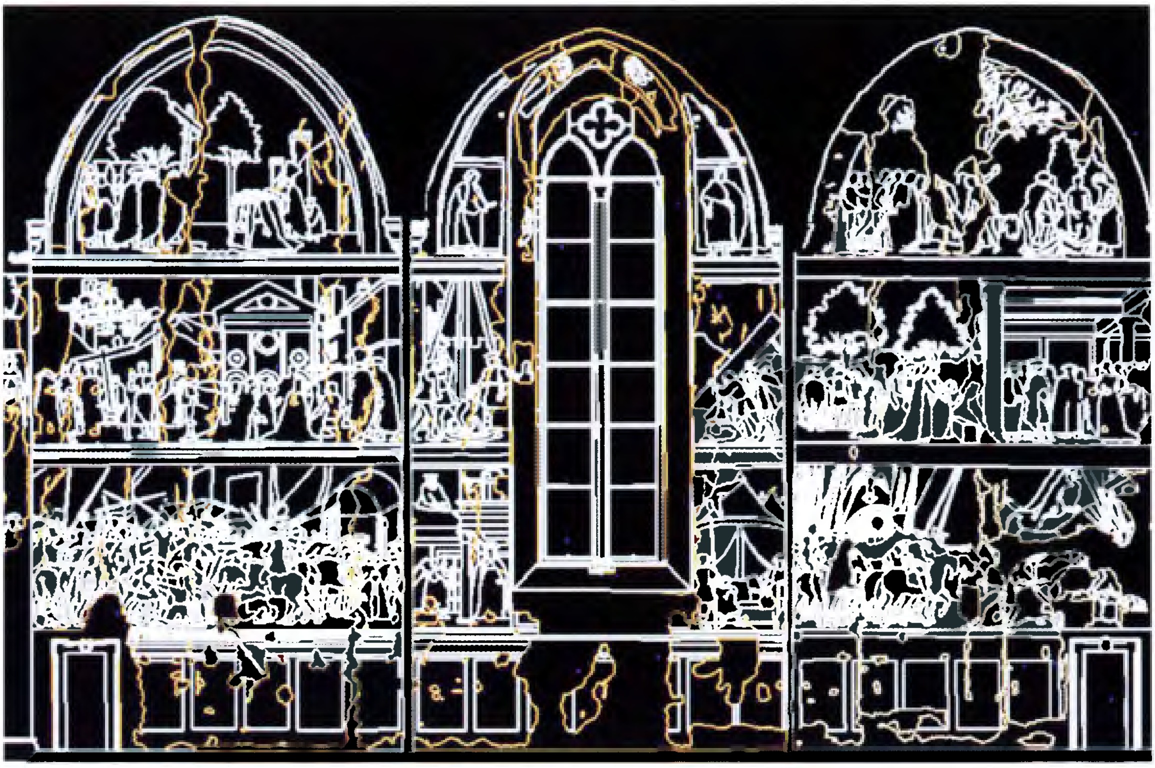

Figure 3. Drawing of the three painted walls. This constitutes the base map over which one can superimpose the numerous thematic maps regarding the diagnostic investigations and the documentation of the restoration.

The complex structure that manages the data from their archiving till their use in the restoration activity contains various innovations, both in the field of information technology and the more specific field of conservation intervention, providing for the first time a close operational relationship between the two spheres.

Although it is not possible here to provide detailed technical specifications of the information technologies employed to create this complex system, it should be noted that the software managing the information had to take into account the different types of data: vector-based (for line drawings, thematic mapping, graphic symbols and patterns); raster (for the diagnostic and documentation photographs); and alphanumeric (for texts, technical forms, historical documents and scientific reports).

The basis is a cartographic-architectural system organized by CAD software, to which are connected a relational database for alphanumeric data and other specific programs for the management of images and of the complex cartographic archive. Parts of these programs were specifically developed for this system.

The CAD system allows the analysis and the association of the different pieces of information, starting from a three-dimensional (3-D) model derived from the photogrammetric survey of the Basilica's architectural structure and of the painted surfaces. The digital drawing constitutes the basic frame for the integration of information deriving from many different fields of investigation. The 3-D model can be visualized by projections, both 2-D (indispensable for an immediate reading of the metric values and used as a base map for superimposing the different thematic maps of the graphic documentation) and 3-D (showing the spatial relation between the different architectural surfaces and facilitating comprehension of the complex structure formed by the building envelope, the scheme by Piero della Francesca, and the determining environmental conditions).

The graphic data relating to diagnostic investigations and the subsequent restoration work were drawn up as thematic maps, which can be superimposed on the photogrammetric line drawing. These maps can be retrieved through special drop-down menus and can be read sepa-

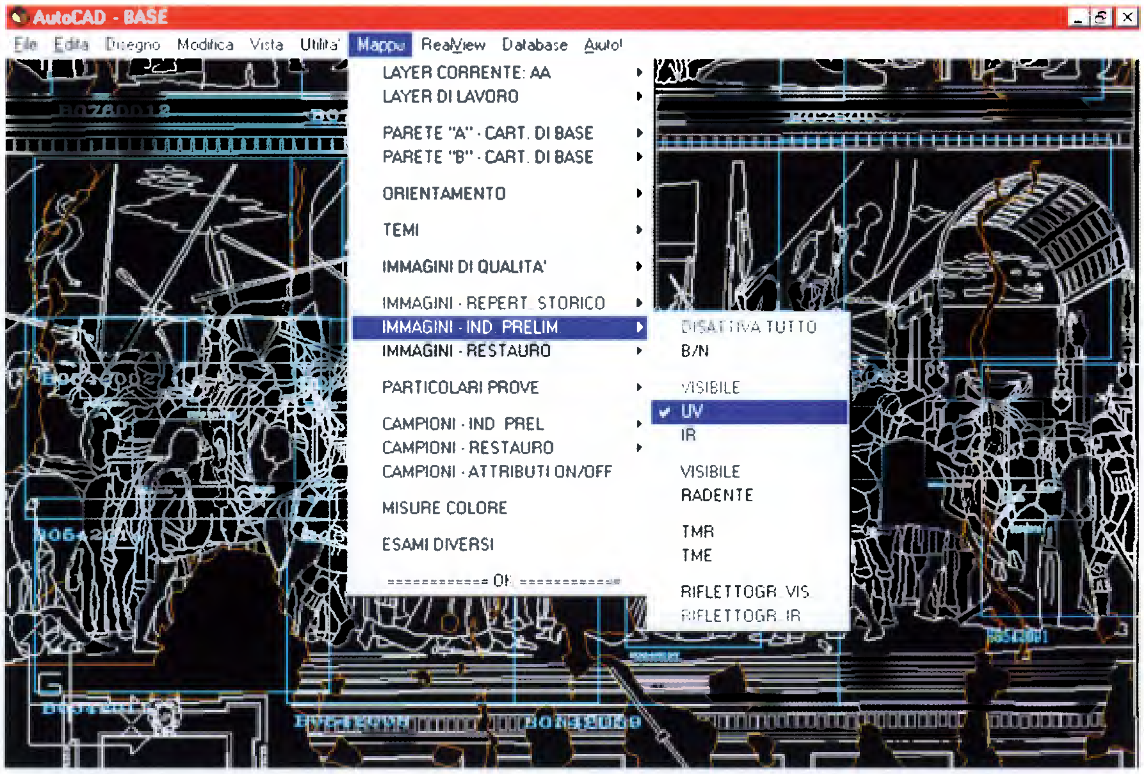

Figure 4. The Archival Documentation System allows easy access to all the archived data. In the image, taken from the *Battle between Heraclius and Chosroes*, one can see the frames relating to UV fluorescence investigations placed over the base map.

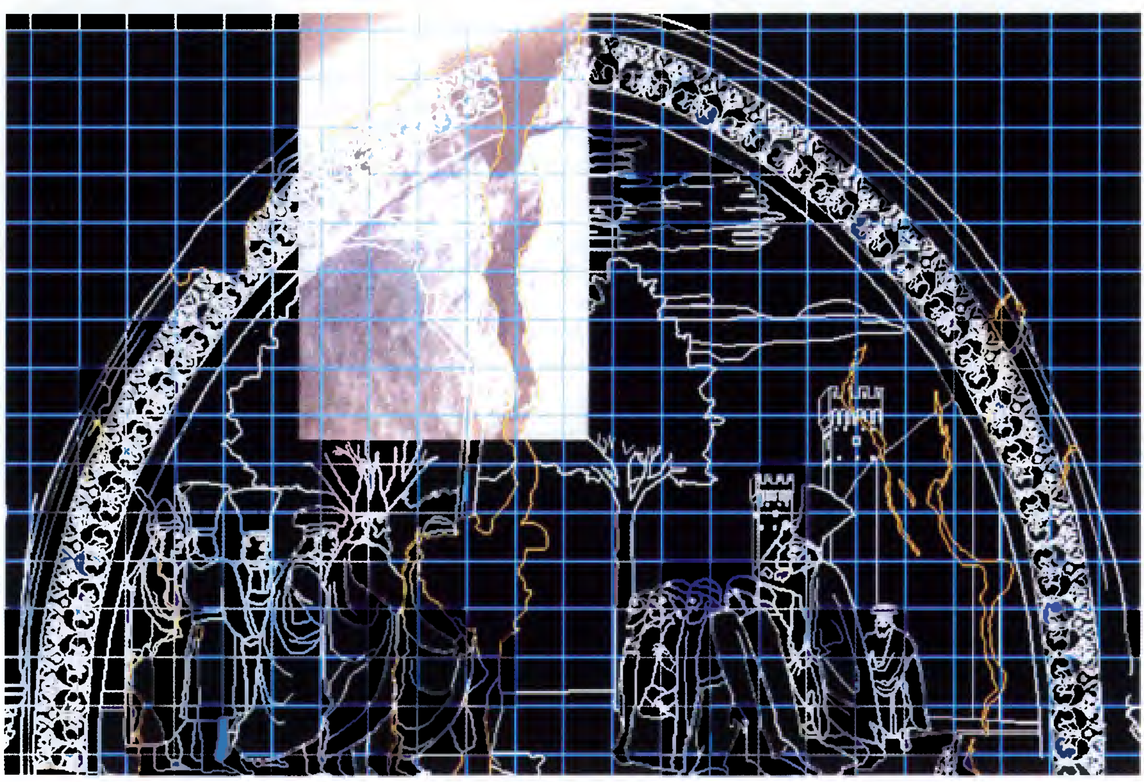

Figure 5. From the *Exaltation of the Cross*: image in raking light overlying the photogrammetric base and the topographic orientation grid.

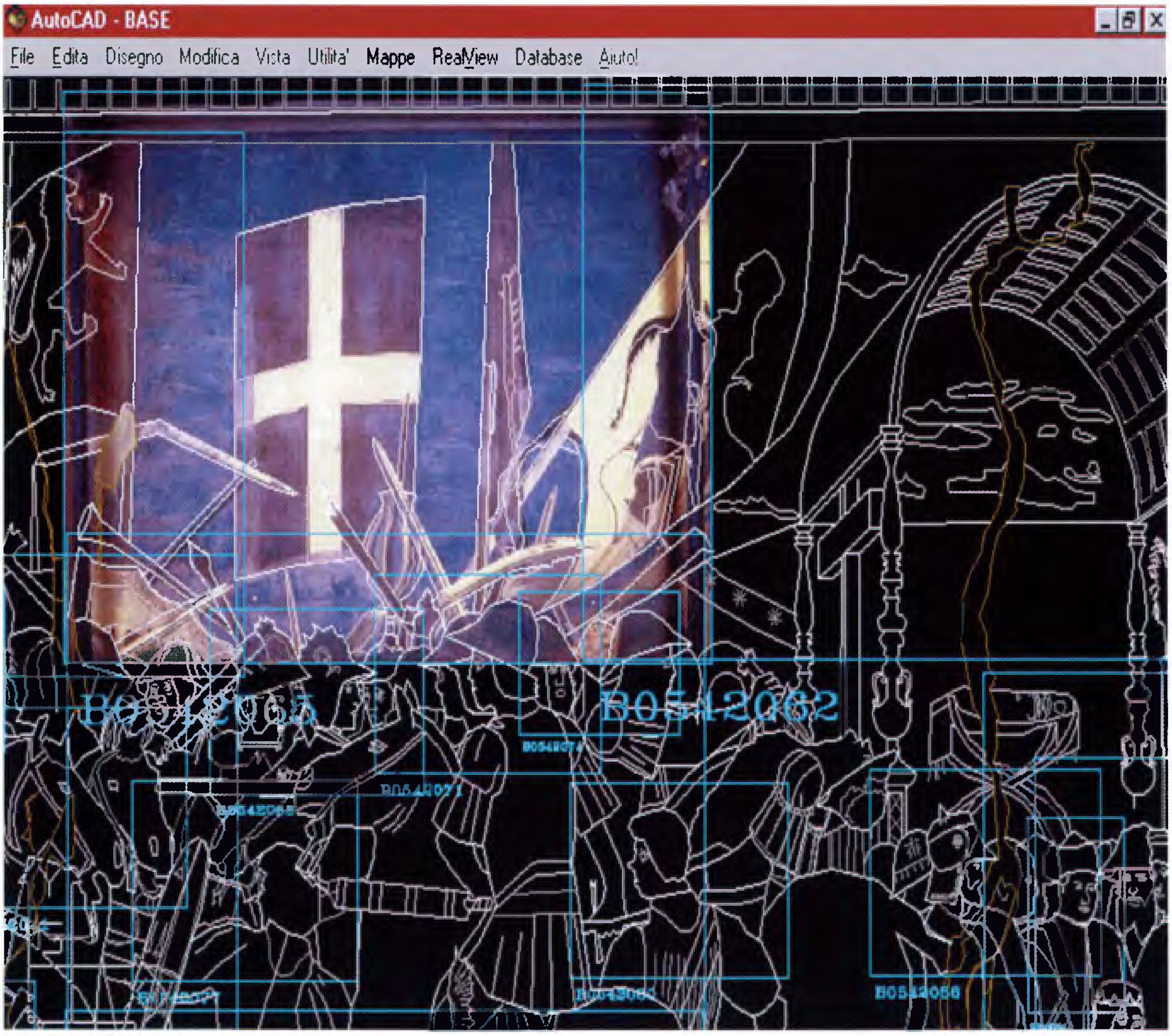

Figure 6. From the Battle between Heraclius and Chosroes, UV fluorescence diagnostic image calibrated over the photogrammetric drawing.

rately or in layers, connecting different information and revealing new correlations between the different phenomena. Moreover, these maps offer a clear and immediate picture, which is of great help for understanding the condition of the work of art and for elaborating the intervention methodology.

Diagnostic and documentation photographs can be obtained by category (i.e. through the thematic maps, both separate and superimposed) and also directly from the computer system, according to a topographic system starting from any portion of the paintings framed on the screen.

On the photogrammetric base, in fact, the various images belonging to the historical repertoire of the archive of the *Soprintendenza*, to the archive of preliminary investigations or to the archive of the present intervention are marked by linear squares, differentiated by colour according to the type of documentation offered, and positioned with their exact proportions and dimensions. Choosing the desired image by clicking directly on the outline of the squares, it appears superimposed on the drawing and can be compared with other images, in their correct position and size. Starting from the chosen image and by using the menu, it is then possible to go to the descriptive texts included in the relational database (concerning diagnosis, historical inventory or the reports of the present intervention). In this way a complete integration of vector type information with raster and alphanumeric types is achieved.

The relational database is organized into a series of categories that, with regard to their information units, specifically defined in their structure and contents, represent a further innovation by SDA. These categories can be consulted by means of different query keys, allowing the user to easily obtain the information needed. Such queries can also be made in the opposite direction, by starting from the texts to reach the corresponding images positioned on the photogrammetric model.

In short, the principal and particularly original aspects of the system are:

- the constitution of a cartographic system on a photogrammetric basis, to correlate the images of the painted cycle with the exact conformation and morphology of the wall surfaces, so that every recorded image and datum is measured and placed in its exact relation with the spatial coordinates;
- the graphic representation of data in synthetic thematic maps, that can be looked up separately or superimposed;
- the close inter-correlation of different thematic information (decay of painted surfaces and masonry structure, previous restoration, methods of intervention, painting techniques, historical information, etc.);
- the creation of a workshop diary by selecting the information and the documentation concerning the restoration, with the possibility of data updating in real time and the production of specific data combinations based on the presence of both texts and images;
- the realization of a thematic glossary, with draft terminology including the keywords for the search and access to data, arranged in technical lists concerning the procedures of intervention; and
- the digital processing of images of high chromatic fidelity produced as part of the photographic documentation of the restoration.

The SDA, being in constant contact with the works in progress, has also played a role in the management of the traditional text and image archives, facilitating access to data, including paper and photographic documents, and their use in a flexible way.

As mentioned above, another of SDA's developments was the acquisition of high-quality images, taken by the photographer of the *Soprintendenza* in Arezzo, Mr Alessandro Benci, according to precise, reproducible criteria.

These images have allowed the digital recomposition on the photogrammetric base of the entire scheme by Piero della Francesca, providing a complete view of a single wall and showing the results reached at the end of the different phases of the treatment. This operation allowed, for instance, the estimation, both in detail and in general, of the chromatic conditions, as well as any other condition, of the painting. In particular, the assembling of the photos taken after cleaning offered an absolutely new overview of the ensemble before the pictorial reintegration, which was impossible to obtain with traditional photographic techniques, considering the obstacles due to the presence of scaffolding.

Furthermore, video-simulations of the pictorial re-integration of fragmentary or deeply altered parts of the paintings were tested, with the twin aims of raising the level of perception and knowledge of Piero della Francesca's work and of providing a guide to conservators for their delicate work of assemblage and integration of the pictorial text, without presuming to make use of these virtual reconstructions in the operative phases.

METHODOLOGICAL ASPECTS OF THE COMPUTER-AIDED SYSTEM

Correctly used computer technology offers many possibilities of application as a support to the management and conservation-restoration of architectural and artistic heritage.

SDA, as developed for the restoration of the pictorial cycle of the *Legend of the True Cross* by Piero della Francesca, is today an innovative methodological approach to the management of data relating to the diagnosis and restoration of wall paintings.

It is a software suite designed to receive data from an ensemble of computerized instruments and to integrate the different aspects of data recording, cataloguing, processing and archiving, resulting in a system capable of managing the entirety of data coming from different fields of research and from the operative phase of the restoration.

It is possible to follow the progress of the work carried out by SDA staff from1991 to 1999 by analysing the individual phases, in particular those concerning computerization of data and design of the system.

When the inspection of all the material available at the *Soprintendenza* and collected during the preliminary investigation (1985-1990) was completed, it became evident that the huge bulk included material that was different with regard to:

- type of support (photographs; negatives; slides; drawings on paper, overlays or films);
- format (from the 24-36 mm slides to the 200-250 mm plates; from A4 diagrams to measured drawings in A0 format or even larger);
- scale of measured drawings, and level of precision; and
- detail and chromatic reliability of photographs.

This initial scenario was unavoidable, considering the long time and the great technical developments between the prints in black and white belonging to the historical archive and the most recent colour slides (not yet showing chromatic alteration due to ageing), or even between the maps by Giuseppe Massetani, dated 1812, and the most recent stereophotogrammetric surveys printed on non-deformable sheets.

To integrate such a mix of material, apart from the new material to be produced during the restoration, it was necessary to establish methods and standards for data acquisition, paying attention to the features of each document and its use in the computerized system.

The extant measured drawings on paper of the Basilica were acquired in vector format, by means of an A0 digitizer, in order to allow their later processing in the 3-D geometric model. In particular, for the three frescoed walls, there was a 1:15 scale photogrammetric survey on which the principal outlines of the painted scenes were given. The vectorized acquisition of this survey became the first frame for the cartographic system on which SDA is based.

The thematic mappings made during the diagnostic investigation (i.e. maps regarding the level of degradation, painting techniques and previous restoration interventions), were inserted by using hatching and by trying to use the same symbols that were used on paper, but with special attention paid to their readability when superimposed, in order to allow their correlation in transparency with the line drawing representing the fresco.

The manually produced maps, considered to be significant for documentation, were scanned with an adequate resolution that would allow for their eventual reproduction at original size.

Documentation and diagnostic photos (visible light, raking light, IR, UV, thermographic, macro-, micro-) were scanned using a Kodak Photo-CD system, in order to obtain a first, transportable, digital archive able to provide images of different dimensions, from the smallest one of 128192 up to 20483072 pixel). These images were saved in JPEG format on the hard disk at an average format of 768512 pixel to allow their immediate display upon request.

Another criterion was used for high quality images, which were scanned at a higher resolution, paying particular attention to the chromatic fidelity of the digitized image.

Regarding the scanning of the many written documents, from the historical ones to the restoration reports, OmniPage OCR technology was used wherever possible; otherwise they were manually typed.

The features of the whole work, the quality of information and the fruition of the information contained in the system thus depended on the choices made during the initial data acquisition phase.

The choice, for instance, to acquire the existing measured drawings in vectorized format allowed us to further process them and to assemble and structure them within a single geometrical environment: floor plans, elevations and sections were brought to a 1:1 scale and positioned into the 3-D of a CAD system. In this way a digital model was created, consisting of distinct 2-D drawings that can be viewed either separately as orthogonal projections or relative to the architectural and urban context through axonometric and perspective views.

Not only for the different architectural elements, but also for the frescoes of the *Capella Maggiore,* it is thus possible to see the spatial relationship between painted scenes on different walls, or to select the frontal view of a single wall for the analysis of specific problems.

As mentioned before, the SDA is a cartographic-architectural system, so the principal criterion for data collection was the positioning of the original data into the 3-D space of the geometrical model.

The first 'container' of the archived information is a CAD program that was customized through the creation of special menus and functions to manage the drawings and the links to the database. The software used by the SDA system is based on AutoCAD Map (we started with AutoCAD 12 integrated with ADE, later upgraded, until currently it uses AutoCAD Map 2000), and customizations used LISP and DIESEL programming. The database was set up using Visual Basic, and the archive file is saved in Microsoft Access format, while the written documents are in Microsoft Word format.

For the complex computer-aided processing needed for the structuring of the documents, and also for assistance during the intervention, the following programs were used:

- AutoCAD for the processing of vector-based drawings;
- RealView for the restitution of images and their calibration on the cartographic base, consisting of the graphic representation of the paintings; and
- Photoshop for the chromatic treatment of the images and the simulation of pictorial re-integration.

One of the most important examples of data processing is the one used for the production of high quality images, for which the best possible chromatic fidelity and a sufficient level of detail for both the photographs themselves and their computer-aided acquisition had to be guaranteed. All steps of this process were planned in advance in collaboration with the official photographer of the *Soprintendenza,* who took the photographs.

In order to control the chromatic reliability of both the photograph plates and the digital images for each scene that was photographed, some shots were repeated to include standard colour reference charts positioned in a frame to provide controls for each side and the centre of the image area.

The focal length, the plate format, the distance from the object and the geometrical resolution for the scanning process were calculated to provide a sufficient level of detail for digital images: this standard was established at one pixel per millimetre on the painting for the photographs taken before and during the restoration, and at two pixel per millimetre for the photographs taken at the end of the restoration.

The photographic plates taken while the scaffolding was still in place are of 130-180 mm format and were taken as much as possible at a constant distance from the object (the plate size scale is about 1:10) to get an acquisition resolution for all images of 300 dots per inch (dpi). For instance, the documentation of the cleaning phase of the left wall required 54 frames, overlapping each other by 300-400 mm (each single acquired image requires about 8 Mb of memory).

The digital rectification of the photos was made using the RealView program. Apart from minor integrations required during work, the photogrammetric survey was used as the metric basis to obtain the reference points for the restitution. The determination of a number of reference points greater than the commonly recommended four points allowed tighter control over the error of single rectifications, which was kept below 2 mm.

Once the processing of single images was completed, they were cut in the overlap area and assembled into a single image, showing one entire wall. When this work was finished, the frescoed scenes could be now seen as a continuous image, both in detail and as a whole.

However, the simultaneous management of about 100 Mb for each scene would have led to unacceptable waiting time to look up the three frescoed walls. For this reason a system was designed that automatically manages images at four different levels of detail: according to the scale of viewing on the monitor, the program automatically calls up the files with the appropriate definition.

The original images were divided into tiles of 1000 pixels each in a way that allows the program to load only the parts visible in the selected frame; for the less detailed scales of viewing, the tiles were compressed in order to form images that cover a larger surface, using the same number of pixels. The system allows us today to view and print images of high quality concerning the conditions of the fresco before the restoration, during the cleaning phase and at the end of the restoration. The most extended images comprise general views of the walls obtained through the mosaicking of the frescoed scenes and decorated bands.

The metric reliability of the images allows, as stated before, the realization of perspective studies, reconstructions and simulations of restoration that, during the delicate phase of the pictorial integration, have been of great and often crucial help for the conservators in making decisions. All documents produced are archived in the memory of the computer system and in backups on CD-ROM, some 14 Gb in total.

The database and consulting system developed through the SDA project constitute today a new approach to information, not only for publishing purposes, but also for comparative studies and scientific analyses based on metrically and chromatically reliable data.

CONCLUSION

SDA, currently reaching its completion, has now fully accomplished the functions required by the restoration. In addition, it has also offered many opportunities for comparison and exchange with numerous conservation technicians and art historians who visited the worksite during the last few years, and who were able to directly evaluate the role of information technology in this complex project.

After the conclusion of the work, the SDA will necessarily see an evolution of its functions. On the one hand, by preserving its structure, it will become the historical archive of the *Piero della Francesca* Project, situated at the *Soprintendenza* of Arezzo, and expected to be accessible to *bona fide* students and experts, according to conditions yet to be finalized. Also, at-distance Internet access will have to be considered, even though it has to be subject to restrictions and limits, considering the copyright in force on State Properties.

Moreover, SDA will be the principal source (if not the only one) of official high quality post-restoration photos of Piero della Francesca's preserved works in the Arezzo area, although for now of the cycle in San Francesco alone. SDA will continue to supply on request, on different kinds of support, other documentation material, such as the historical documentation before and during restoration, together with any technical data and further information about the intervention.

In particular, thanks to its innovative and interactive character, SDA will be a primary reference resource for future research on Piero della Francesca's work in all its manifold aspects. Apart from those who have already taken part in the restoration and are about to deliver their report to the scientific community and the general public, everybody who wants to deepen their own studies of Piero della Francesca's work will profit from SDA (and possibly further extend the potential of the system) and from the new and increased knowledge obtained in these years through the project.

And once again, the particular richness of the documentation, together with the remarkable quality of the database and of the computerized products, will allow the production of many other didactic, popular thematic and specialized materials, for example on CD-ROM. We identified and exploited only a small part of this potential during the last few years, because our energies were concentrated on the restoration and its daily documentation needs. CD-ROM programs, videos and other products have already been proposed, as well as the creation of a documentation centre dedicated to the restoration of the *Legend of the True Cross* to be open to the public, in a location still to be determined. Such a centre will necessarily have SDA as its heart and mind.

All these further developments, already awaited by many people, are nevertheless independent of the specific functions and value that SDA gained within the context of the restoration as a precious interactive archive, and deserve further energy and investment.

For sure, the flexibility, the complexity, the richness and the quality (from all points of view) of SDA will allow the production of a great range of conceptual products starting from a data processing level that is already well advanced. As technicians belonging to a public heritage agency, our desire is to succeed in keeping adequate control and a high-profile role in this new future phase of SDA development, maintaining a high level of scientific and technical content, as the extraordinary artistic synthesis of *Piero della Francesca*'s paintings deserves.

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All software names used here are trademarks of the respective trademark owner: OmniPage by Caere; AutoCAD by AutoDesk; Real View by Vectar s.r.l.; Photoshop by Adobe; Access and Word by Microsoft.

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3-D VISUAL INFORMATION AND GIS TECHNOLOGY FOR DOCUMENTATION OF WALL PAINTINGS IN THE 'M' SEPULCHRE IN THE VATICAN NECROPOLIS

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ABSTRACT

Digital technologies can be very helpful in the graphic documentation of paintings, not only for the inherently more detailed and faster method of drawing, but, in particular, for 3-D representation of data (structures and materials) in real time, with the possibility of having many dynamic views of the same model so as to visualize and interpret the features, shapes and condition of structures and materials. Moreover, it is very important to highlight that paintings or mosaics are intelligible as 3-D objects rather than 2-D objects, since they do represent solid objects. Using Geographical Information System (GIS) technology for collecting data, it is possible to process the relevant information in detail.

There are many situations to be faced in the graphic documentation of surfaces, whether flat, bossed or curved, with or without decorations. The traditional form of graphic documentation, interpretative by definition, favours different levels of detail, depending on the scale of reduction and the different objectives under study (location of degraded areas as opposed to decorated; presence of discontinuity and cracks; production of images and thematic maps derived from particular analyses such as Thermal Infrared surface scanning). The documentation of a decorated vault is difficult to produce, so we have chosen to consider the walls and the polychrome mosaic vault of the 'M' Sepulchre, also known as Cristo Sole (2nd-3rd century AD) in the Vatican Necropolis. The mosaic presents a small tessera decoration (of which only a fraction is still in place) on the walls and on the very low vault; where the tesserae are missing, the remains of the mosaic setting bed enable us to interpret the original decoration.

Furthermore, the main goal of the project is the virtual detailed 3-D reconstruction of a micro-model of these decorations, using digital techniques, in order to have a final 'cognitive' representation. For this, we have used new tools for the acquisition of detailed 3-D surfaces.

The general positioning (geo-referencing) was achieved using a Leica TCR 1103 total station; this instrument also enabled us to obtain vast amounts of surface data for the 3-D model thanks to its reflectorless Laser Electronic Distance Measuring (EDM) range

finder. Where more detail was necessary, further surface data was gathered using a Microscribe 3-D Mechanical Arm Digitizer coupled to a laptop computer and driven by the Rhinoceros 3-D surface modelling software.
The project involved: digital acquisition of surfaces, digital documentation of mosaics and paintings, 3-D virtual reconstruction of models, and 3-D virtual communication of the information by Virtual Reality Modelling Language (VRML) metaphors through Internet.
KEYWORDS: *micro-GIS; 3-D; 'M' Sepulchre; Cristo Sole; Vatican Necropolis; virtual reconstruction.*

INTRODUCTION

The graphic documentation of wall paintings and of the underlying architectural or archaeological structures must be implemented at the highest level of knowledge and communication.

However, no matter how objective and metrically correct such documentation may be, whether obtained through traditional means or through the use of more advanced systems, such as photogrammetry, it is still subject to the interpretation of the documentalist. This does not mean that we must not search and, through experimentation, choose whichever methodology is best suited to tackle the diverse situations one may encounter.

In every documentation project, the first step is the creation of a spatial reference system for the proper positioning of all the elements under study, both in absolute terms and in relation to each other, independent of scale and complexity. Thanks to recent technology advances, this portion of the task has been greatly simplified. New options and equipment are also coming to aid us in the subsequent part of the graphic documentation process: the actual retracing of the objects of our study, either in high detail (as favoured by historians or archaeologists) or more schematically (to create a basis for the conservator's thematic mappings).

Digital technology may be very helpful in the graphic documentation of wall paintings – not only for its greater speed without compromising on detail, but also for representation of data (structures and materials) in 3-D. Thus there is the possibility of having many dynamic views of the same model in order to visualize it and thus to interpret the features, shapes and condition of structures and materials in real time. Moreover, it is very important to highlight that paintings or mosaics are more understandable as 3-D objects rather than as 2-D objects, because they represent a 3-D class. Using Geographical Information System (GIS) technology, it is possible to process the collected data in detail in order to interpret and analyse the digital content with multi-dimensional levels of overlay.

For this reason we have identified the following goals for the methodology:

- Testing new systems for micro-topological survey in emergency situations (very small spaces, detailed architectural features, preservation of the materials).
- Considering digital graphic representation of mural paintings and mosaics as three-dimensional information (and not two-dimensional).
- Using 3-D GIS techniques for an interactive visualization of architectural models and 3-D databases.

On the basis of the above criteria, the main stages associated with the 'M' Sepulchre work were:

- Digital acquisition of all the architectural surfaces with a 3-D pantograph (Microscribe, see: http://www.immerse.com/microscribe/digitizers.html), making a total of 11 000 points.
- Rectification and digital photomosaicking of the irregularities of all three walls and the vault.

- Infrared thermal survey (thanks to the support of National Atomic Energy Agency –ENEA).
- 3-D interpolation of the micro-relief data.
- Digital data entry into a 3-D GIS.
- Texture mapping and draping of all the graphic surfaces on the micro-DEM [digital elevation model] of the walls.
- Virtual reconstruction of the tomb in Virtual Reality Modelling Language (VRML).

THE VATICAN NECROPOLIS

The work presented here was carried out during restoration works in the Vatican Necropolis (Guarducci, n.d.; Apollonj Ghetti *et al*, 1951). This once open-air burial ground is now buried under the nave of St Peter's Basilica. In fact, the Necropolis was covered up when the Constantinian Basilica was erected, and successive burials have altered the stratigraphy of the site, as have the structural works for the construction of Bernini's *Baldacchino* and the sequence of altars constructed, over many centuries, on top of the sacred spot considered to be St Peter's burial site. Currently the Necropolis is found with walls of considerable size and in good condition, though the view is at times obstructed by modern pillars needed to support the structures above. These were added after removal of the soil during the excavations carried out in the early 1940s. The explored area of the Necropolis covers an area of about 69 x 18 metres; it has a double row of burial edifices separated by a narrow passageway. In particular, the 'M' sepulchre is inserted between two other structures of which it uses the outer walls; this makes it one of the last, chronologically speaking, constructions of the Necropolis.

THE 'M' SEPULCHRE, KNOWN AS *CRISTO SOLE* (CHRIST THE SUN GOD)

The 'M' sepulchre was discovered in 1574 during an excavation carried out under the floor of St Peter's Basilica; on that occasion, thanks to the discovery of an epigraph (of which only the transcription of its text has reached us) and through the study of the wall typology, it was possible to suppose an originally pagan structure, datable to the mid-2nd century AD, and its successive transformation into a Christian mausoleum at the beginning of the third. A very rich mosaic decoration originally covered the upper portions of the walls and the whole vault, while the lower portions of the walls were decorated with geometrically patterned frescoes. Today, the mosaic decoration is partly missing, although it is possible to trace the original designs thanks to the traces left by the lost tesserae, which indicate the 'M' sepulchre as the only entirely Christian burial in the Necropolis. On the setting bed of the mosaic on the west side we can catch a glimpse of the Good Shepherd; on the frontal (north) scene we can see the Fisherman (Christ or Peter) with a fishing rod; on the east side, Jonah swallowed by the Whale; and finally, on the vault, the image of Christ as the Sun God, ascending to the sky on a four-horse chariot surrounded by intertwined vine branches and leaves. The complexity of the structure and the decorations and the indubitable importance of this sepulchre were decisive factors in selecting it as an example for testing the integration of different documentation and analysis methodologies.

THE MICRO-TOPOGRAPHIC SURVEY

The survey and graphic documentation of the plan of the Necropolis was carried out (using a Sokkia SET 4C total station – **Figure 1**) by creating an accurate surveying base through the establishment of a closed traverse with branches entering into each and every mausoleum; this resulted in the placement of around 70 instrument stations. All mausoleums were documented in detail, with all documentation referable to the topographical base (**Figure 2**).

The surveying instrument also proved very useful for recording the salient points necessary to carry out a metrically correct documentation of wall paintings and architectural decorations, even through the subsequent use of traditional means (measuring tape, plumb bob, level, etc.). When faced with the particular conditions posed by the 'M' Sepulchre it was decided that a more unconventional approach might not only simplify the task but also offer the capability of representing the object of our study in a radically new way: by virtually recreating the actual surfaces of the walls and vault, in full detail, with the obvious superimposition of the decorations (mosaic or painting) they were adorned with.

Although the concept of a computer-generated 3-D model was not new, it had always been applied to generate, at the most, schematic examples of structures on which to project the images of any surface texture, obtaining a great general effect, but still hardly useful for purposes of study. We were encouraged by the availability of two new instruments: a total station (Leica TC1103) equipped with a coaxially (along the line of sight) mounted reflectorless electronic distance measuring (EDM) laser (not needing reflecting prisms to measure distance) and a 3-D digitizing arm, which is a sort of 3-D pantograph (Microscribe 3-DLX).

A few words on this last item: the Microscribe is a 3-D digitizing (**Figure 3**) precision mechanical arm in which high performance sensors embedded in its articulated joints track the position and orientation of the stylus tip as it is moved in space by the operator. By pressing a button or a foot pedal (depending on the accessory in use), it is possible to record the relative spatial position of the tip at any given moment and, through a serial connection, send such data to a computer. There are many CAD and/or 3-D oriented software suites capable of making use of such input just as if it were coming from a mouse or digitizing tablet (with the fundamental difference of the 3-D nature of such data). Moreover, the system is highly portable: whether it is set on a table simply sitting on its base or on a tripod, it can be placed just about anywhere provided there is a power source and a connection to a computer (a portable computer, for example). Not only is it possible to record single points, but also streams of points by keeping the input button or pedal continuously pressed while the stylus tip is passed over the object to be digitized; this method is particularly indicated in association with software that makes use of 'point clouds'. Since the first three points recorded during a digitizing session are used to establish the reference plane to which all successive points are referenced, it is also possible to fix, in a different area, another set of three points during the same session to be used as reference points for a subsequent session; this enables coverage of much wider areas, far beyond the actual reach of the digitizer. As a last consideration we must not underestimate the intuitive facility of the device, where the operator is always in total control of all activity.

With these instruments, we were able to accurately reproduce a virtual representation of the actual surfaces in extreme detail and accuracy, and plot only points or lines. The 'M' Sepulchre presented various characteristics such as frescoed and formerly mosaic-covered wall surfaces, and a vault with a rather undefined shape (a very low cross vault) only partly covered with the polychrome mosaic that once characterized the whole upper portion of the sepulchre.

The first step was to place the laser EDM total station inside the mausoleum onto a predetermined station tied to the main traverse used in the survey of the Necropolis plan. Through the use of this instrument we were able to scan the various wall and ceiling surfaces, carefully distinguishing the brick and plastered surfaces of the left wall, the mosaic setting bed, the corbel and the frescoed lower portion of the front wall, the setting bed and fresco of the right wall. Furthermore the total station was used to record points for the spatial referencing and geometric rectification of the photographs of the various surfaces. Finally, we recorded the points to be used later to reference 3-D digitizer survey sessions (3 points for every session).

The 3-D digitizer was used to retrace the outer contour of the only remaining portion of the mosaic placed on the vault, point by point. A series of parallel lines running over the vault's surfaces were also digitized to be used as a basis for their reconstruction. This procedure was chosen because there was insufficient clearance between vault and total station for the laser rangefinder to work properly. All the frescoed designs and the traces of figures, left on the lost portions of the mosaics, were digitized with the Microscribe Arm and, as a further test, a detail of the face of Christ was digitized tessera by tessera before the conservation operations.

At this point we had a clear indication of how helpful these techniques were in obtaining metrically correct graphic documentation directly on site, through the detailed examination of all elements necessary for the interpretation and comprehension of the structures and decorations.

The software used in connection with the digitizing arm (Rhinoceros 3-D, **Figures 4-5**) not only provided an interface between instrument and user, but it also permitted us to digitally recreate shapes, lines, curves and surfaces in their exact spatial position and, most useful of all, in real time.

This data, through further processing, was instrumental in the construction of our 3-D model, to be used either for the extraction of 2-D representations by projecting it onto whichever plane we desired to observe it on, or, by retaining its 3-D characteristics, use it in one of the many applications that made use of spatially defined entities. The model thus created was, for example, used to map the information gathered during a thermal infrared scanning analysis carried out on the frontal (North) wall of the Sepulchre.

To insert the infrared imagery and the result of its processing into our metrically correct representation of the wall, a series of reference marks, visible both in visible and thermal infrared bands, were placed on the surface and surveyed.

The thermal infrared scanning (**Figure 6**) was carried out with the Marconi TICM II, a high-resolution system, operating in the 8-13 micron wavelength range. The images were processed through dedicated software by Media Cybernetic, applying the appropriate filters to enhance readability.

In the example image (rendered in pseudo-colour, **Figure 6**), captured during the cooling phase, we see a presence of warmer areas (yellow-red) which correspond to possible slight detachments of the plaster layer from the brick surface. The cooler (blue) areas indicate the presence of a humidity front. By processing the infrared image, we can produce thematic maps, and in this particular case we have recorded and outlined the above-mentioned areas.

The software used throughout our documentation campaign was AutoCAD for the acquisition and projection of topographical data, CAD Overlay for the processing of orthophotographs and Rhinoceros for 3-D digitizer data acquisition and subsequent modelling of the various surfaces.

Rhinoceros, in particular, is a tool that enables us to produce mathematically defined (NURBS) surfaces (as opposed to Triangulated Irregular Networks (TINs) or grid meshes) by combining a series of parallel or criss-crossing curves. The most complex surface to process was certainly the vault: not only because it consisted of two separate surfaces (mosaic and setting bed), but also due to its irregular geometric shape.

Through the use of the curves obtained by 3-D digitizing, the software enabled us to digitally reproduce nearly exact replicas of the surfaces and to project images or drawings onto them.

In short, we started with a decorated surface; we surveyed it, obtaining a 3-D model; and we then digitized its decorative elements in order to obtain a metrically correct base for their successive manual graphic documentation. At this point we are able to re-integrate the surfaces with their now spatially referenced pictorial images in order to be able to view the complete model from different viewpoints.

GIS AND VISUAL INFORMATION

The main goal of our project was the virtual detailed 3-D reconstruction of micro-models of paintings documentation by digital techniques and through different information layers, in order to have a final 'cognitive' representation (Forte, 2000). In the case of a monument, such as a tomb, the best cognitive micro-representation increases the level of knowledge and of interpretation, practically de-constructing, in a first phase the pictorial and architectural information; subsequently recombining every component of the structure into a unique, whole virtual model. The process of de-construction and re-construction is a cognitive dynamic process of knowledge that we think is fundamental for a new approach to digital graphic representation: we disassemble and then reassemble information. Thus a model becomes an articulated set of multilayered information elements, where the whole increased model is more significant than each single component.

In this context, 3-D GIS and virtual reality technologies have been fundamental in obtaining good results. In fact, even though GIS software is typically used in territorial studies and analyses, it can give very interesting results also in other non-traditional contexts. Furthermore, we have to consider GIS as an open planning platform, where the scientific user chooses the directions of research, combining the several layers of documentation.

All phases of the work were carried out by exchanging all the data on-line (by Internet tools) and creating a network of persons with different roles and functions: topographic survey and acquisition (A. Bizzarro, S. Tilia), data processing (S. Tilia), rectification and topological referencing of the images (A. Tilia), GIS implementation and 3-D processing (M. Forte), VRML reconstructions and virtual reality applications (A. Tilia, S. Tilia, M. Forte).

In order to process the digital data the following software was used:

- Er Mapper 6.1 (3-D visualization and draping, infrared spectral analysis);
- ArcView 3.1 (GIS data-entry and overlay); and
- VRML Cosmo Player (3-D visualization of the model reconstructed).

In our case, the most important phase of the work was the superimposition of the data, that is the representation of the data in a unique referenced coordinate system, through the exact use of a GIS implementation.

Starting from the importing of data into the GIS, the main steps of the working project were:

- Data entry of vector (drawings) and raster (images) files (**Figure** 7).
- Topological referencing of raster (photomosaics and graphics) and vector (decorations, drawings) layers in ArcView (**Figures 8-9-10-11**).
- 3-D interpolation data by CAD and GIS software (ArcView 3-D Analyst) for the creation of 3-D surfaces (interpolation by Grid and by TIN, **Figures 12-13**).
- 3-D superimposition of all the geometric and graphic layers (**Figures 14-16**).
- 3-D texture mapping of the graphic documentation over the model and draping of all the referenced data over the micro-DEM of the walls and of the vault.
- Real time visualization of the virtual models (in our case, four models for the documentation of the tomb) using Er Mapper and the 3-D Analyst module of ArcView (**Figure** 17).
- Merging of all types of data systems in order to analyse and to compare the different information layers (raster and vector, including images, contour lines, polylines, graphic edges, interpretations and so on).
- Z exaggeration of the interpolated models in order to stress the surfaces for testing the condition of the mural paintings, and the relationships between mosaics, graphic decorations, architectural elements, loss of materials, etc.
- Model reconstruction in VRML (see below) in order to view and interact with the data on-line in Internet or off-line on any PC.

One of the most important final steps of GIS applications should be the communication of available data on-line. The chance to put information (raster, vector, 3-D, etc.) on the Internet gives scholars and others the possibility of accessing remote systems to compare and analyse data and finds. The development of multimedia applications within a GIS environment is now in progress and represents one of the most interesting possibilities for communicating information in the future. In particular Internet or a net of geo-referenced 3-D databases and graphic libraries could constitute the final goal of GIS, giving the users the possibility to obtain and add information in real time. In our case, using the 3-D analyst module of ArcView, the GIS 3-D models were reassembled in VRML 2.0, so as to explore them interactively through Internet browsers.

3-D INTERPOLATION

Interpolation methods allow the creation of 3-D surfaces starting from scattered altimetric points (or Z values). The choice of the method of interpolation influences the interpretation of the model, so it is important to know the main techniques in order to obtain good results. In fact, topographic, topological or digital terrain data, once gridded, can be processed and displayed to highlight important physiographic or geometric features, or both, in territorial or architectural contexts. The release 3.0a of 3-D Analyst uses two methods of interpolation, Grid and TINs.

- Grid interpolation is a representation of surfaces using a mesh of regularly spaced points. The grid model is simple, and processes using this feature tend to be more efficient than those of other models. Elevation data in grid format is relatively abundant and inexpensive. However, the mesh structure prevents linear features from being represented sufficiently for large-scale applications.
- In contrast, TINs represent surfaces using contiguous, non-overlapping triangle facets. One can estimate a surface value anywhere in the triangulation by averaging node values of nearby trian-

gles, giving more weight and influence to those that are closer. The resolution of TINs can vary, because they can be more detailed in areas where the surface is more complex and less detailed in areas where the surface is simpler. The coordinates of the source data are maintained as part of the triangulation, so subsequent analysis, like interpolation, will produce the source data precisely; no information is lost. Unfortunately TINs tend to be expensive to build and process. The cost of having good source data can be high and processing them tends to be less efficient than grids. We can consider this step a detailed 'microrelief' of the structures.

VRML RECONSTRUCTION

VRML is a 3-D modelling language for virtual reality applications using 3-D scenes. On the basis of the definition of the VRML consortium, VRML is an open standard for 3-D virtual and multimedia worlds, connected and linked by Internet. In December 1997, VRML was classified as an international standard (ISO/IEC-14772-1:1997) by the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC).

Hence VRML was created in order to permit standard access on the web to interactive virtual environments; in fact, in only a few years, it has become the most used language for the representation of 3-D scenes on-line. Furthermore, the new powerful versions of VRML (2.0 and VRML97) allow specific tools for animations and interactions with the users – very important in the field of virtual reality.

Furthermore, in our project, after the GIS applications, we completed the 3-D reconstruction of the tomb in VRML, so that the whole monument could be explored in real time, including textures (photo-mosaics of the walls) and geometry.

The VRML model can be viewed using freeware browsers that can be downloaded from the Internet; to view our reconstruction we use Cosmo Player (created by Silicon Graphics, http://www.cai.com/cosmo/). In this way, access to VRML models is open to everybody. For instance, the 3-D models were created and explored using Cosmo Player 2.1 (Silicon Graphics) as browser. Using the virtual console of the browser, and viewing the model, it is possible to move forward and back, turn left and right, tilt up and down, seeking, sliding, and so on. The interaction in real time and a user-friendly interface allows us to describe the model as a cognitive model: in fact during the virtual navigation we perceive new information and new ways of visualization, without the need to have GIS software for representing the data.

CONCLUSIONS

The digital project of the 'M' Sepulchre of *Cristo Sole* demonstrates that a visual information system can be very important for providing a deep knowledge of a monument and of the pictorial content, whether for scientific analysis or technical communication (digital editing). In fact, the key point of the project was to test the possibility of using GIS systems in "monumental archaeology", integrating 2-D and 3-D data sources. In this case we can talk of enhanced reality, because the digital technologies have introduced new levels of information, completely unknown before. In particular, this approach opens new directions for graphic representation, mainly because it encourages us to visualize multiple dynamic models, not just a simple drawing. An open platform, such as GIS or other specific visual information systems, provides the scientific community with the opportunity to interact, step by step, with a universe of information, always updateable and constantly increasing. Indeed, it is important to highlight that a virtual model is an open model that can be extended with further documentation and interpretation layers.

The use of a 3-D tool (Microscribe arm) for creating the models has shown us another innovative system of micro-survey: in a single operation it is now possible to draw graphic outlines and to record the architectural geometry, verifying, point by point, the shape and dimensions of the 3-D surface.

Finally, we can briefly summarize the main results and the significant prospect that this project opens:

- ***3-D data acquisition*** New tools for 2-D and 3-D data-acquisition through the use of a digital pantograph (Microscribe arm) have shown great potential for micro-topological graphic documentation, mainly in situations where it is difficult to operate with other systems.

- ***3-D Visual Information*** by use of GIS application and spatial analyses. The creation of a visual information system (in our case GIS) has involved a different approach to the graphic representation of mural paintings. A dynamic visual model can provide new perspectives in the study, analysis and scientific communication of painting documentation.
- ***3-D multilayered analysis.*** The combination and the overlay of different sources of data increase the level of knowledge about a site on the basis of data crossing; i.e. more advanced interpretation depends on the superimposition of referenced data.
- ***Monitoring of the monument through time.*** For monuments such as the *Cristo Sole* tomb, it is fundamental to monitor the condition, primarily analysing all the factors of alteration (chemical, physical, architectural) in a multilayered visualization (through the superimposition of graphic information).
- ***3-D virtual reconstruction.*** By assembling every 3-D component we have the possibility of viewing and studying the model through an interactive and full visualization, in particular by eliminating difficulties existing in real views on site.
- ***Future applications.*** The next possible application regards the creation of a complete 3-D database of the Vatican Necropolis, with further information layers holding the results of non-destructive chemical and physical analyses.

ACKNOWLEDGEMENTS

Special thanks are due to Cardinal Virgilio Noè, President of the *Fabbrica di San Pietro*, for having authorized the publication of this paper, and to ENEA for the thermal infrared analysis.

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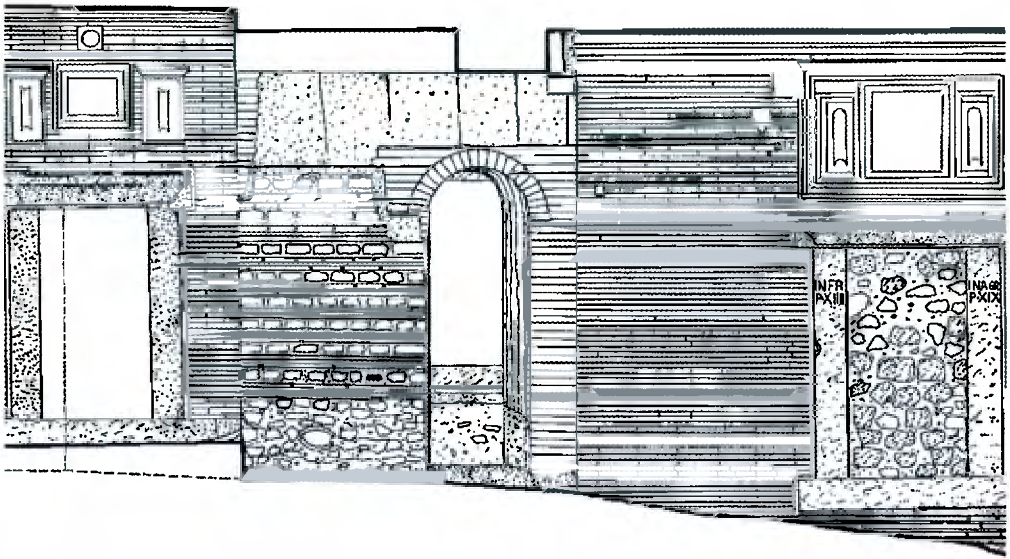
Figure 1.



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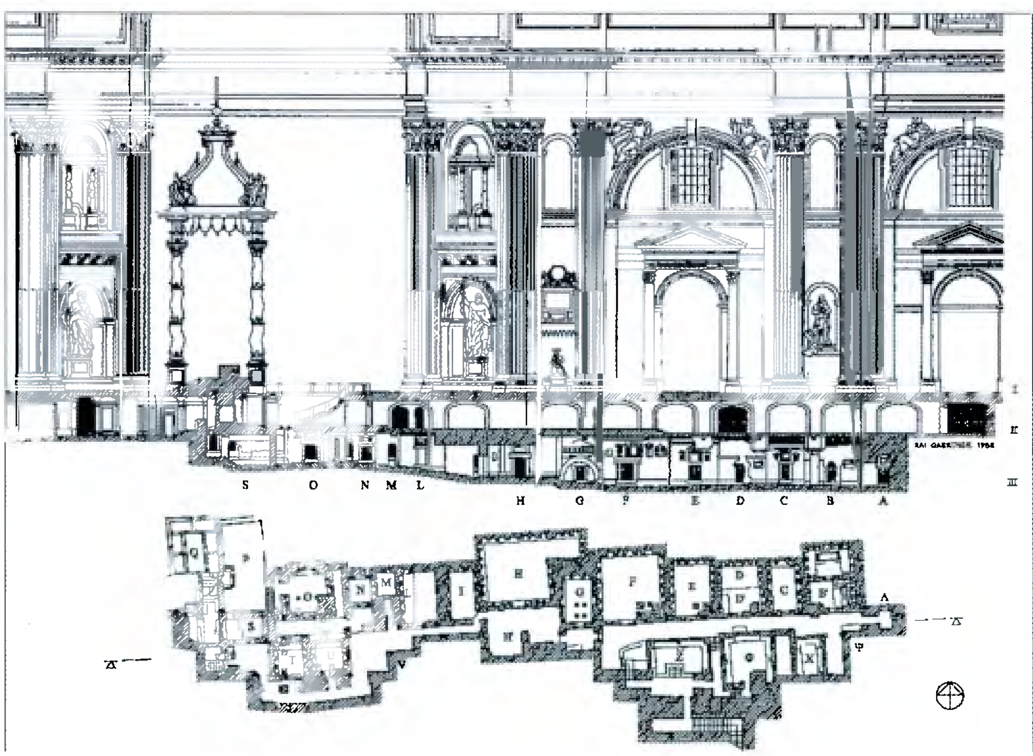

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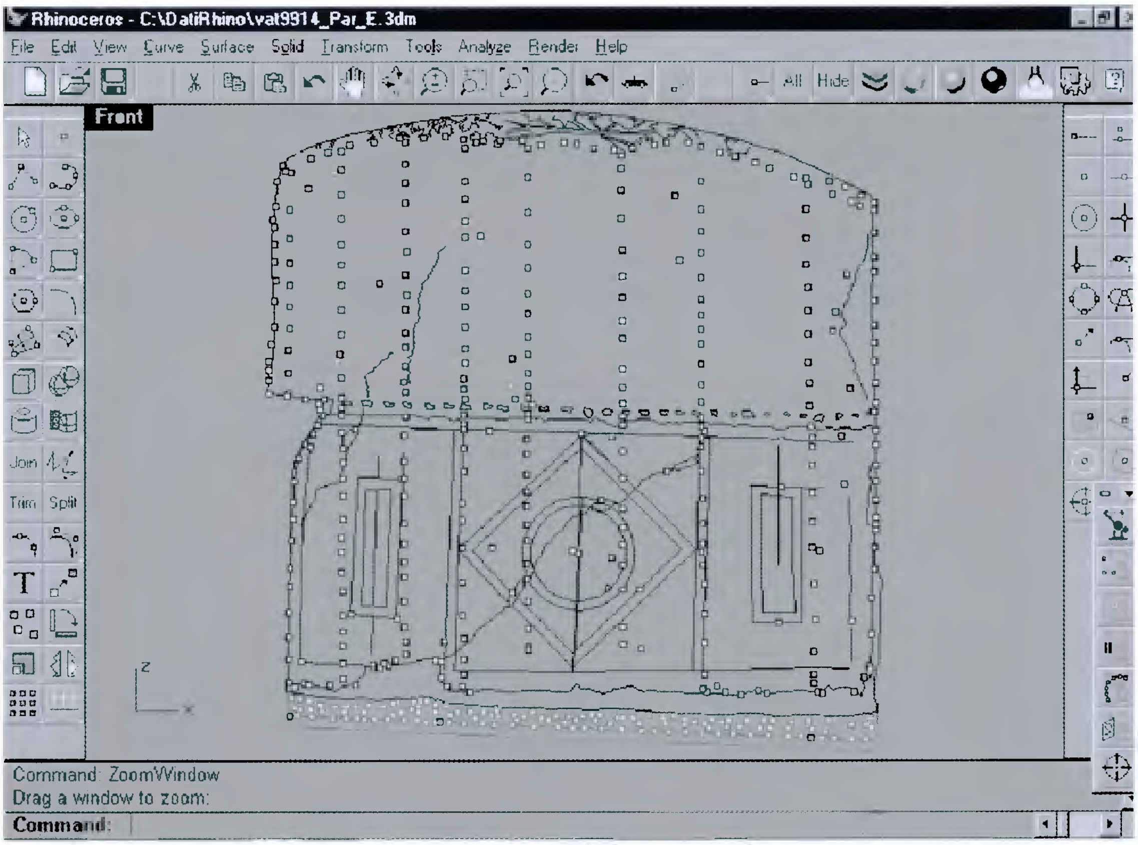

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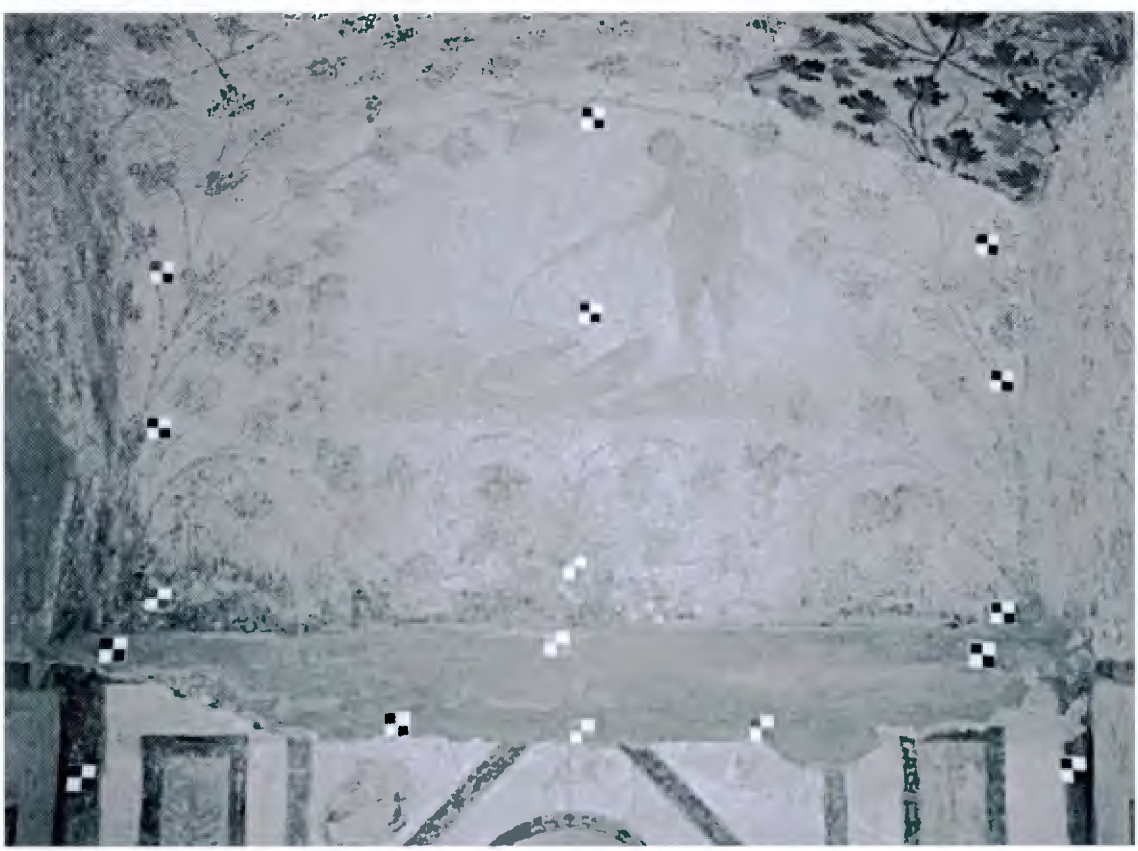

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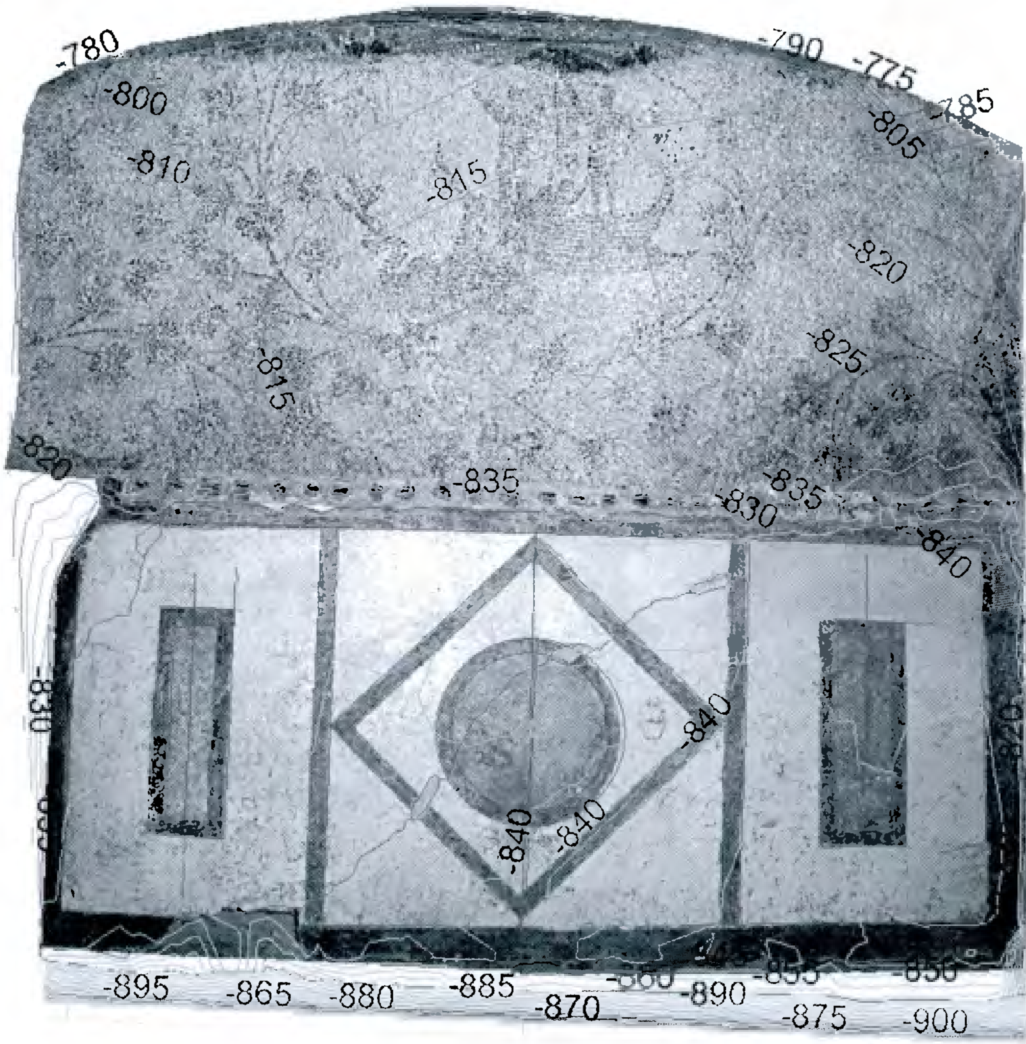
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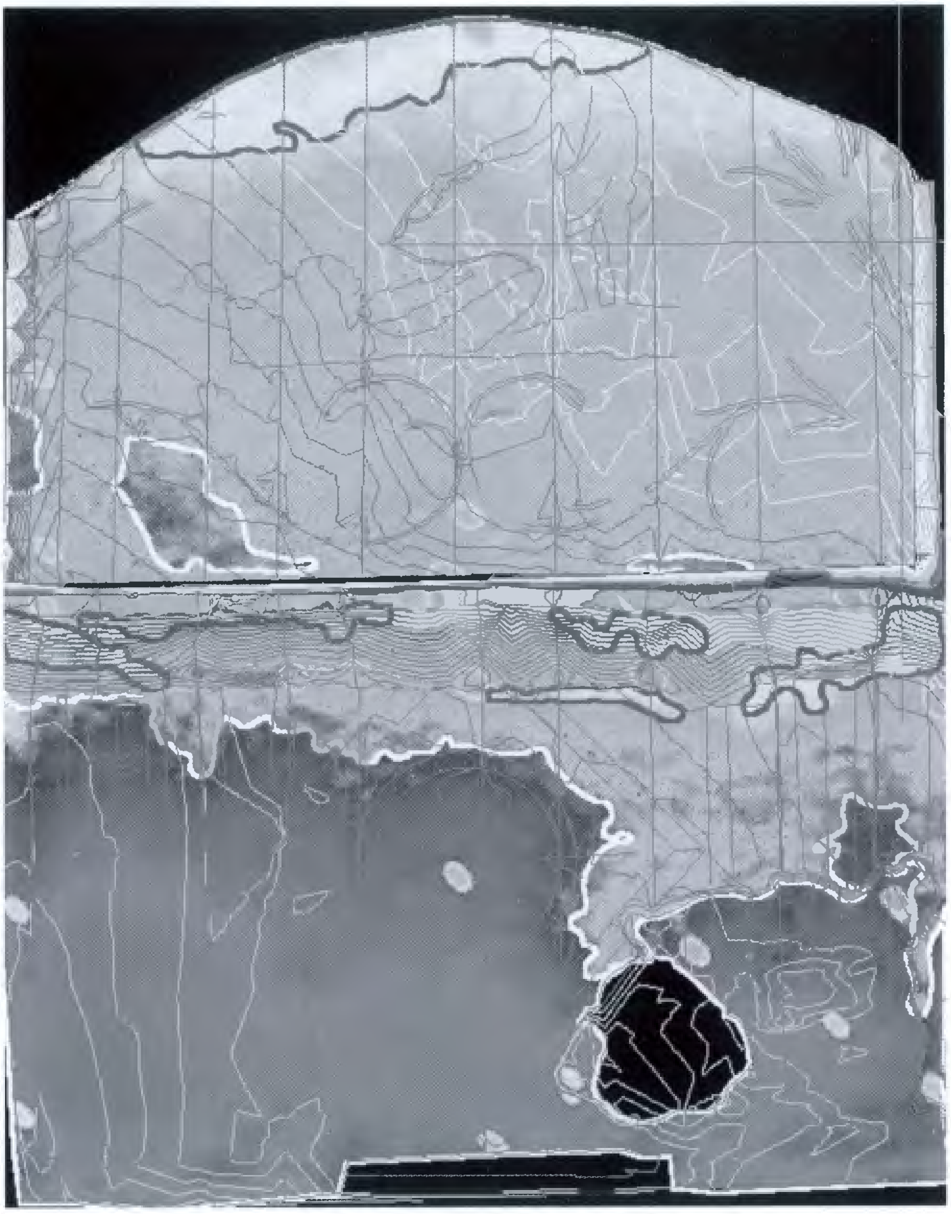

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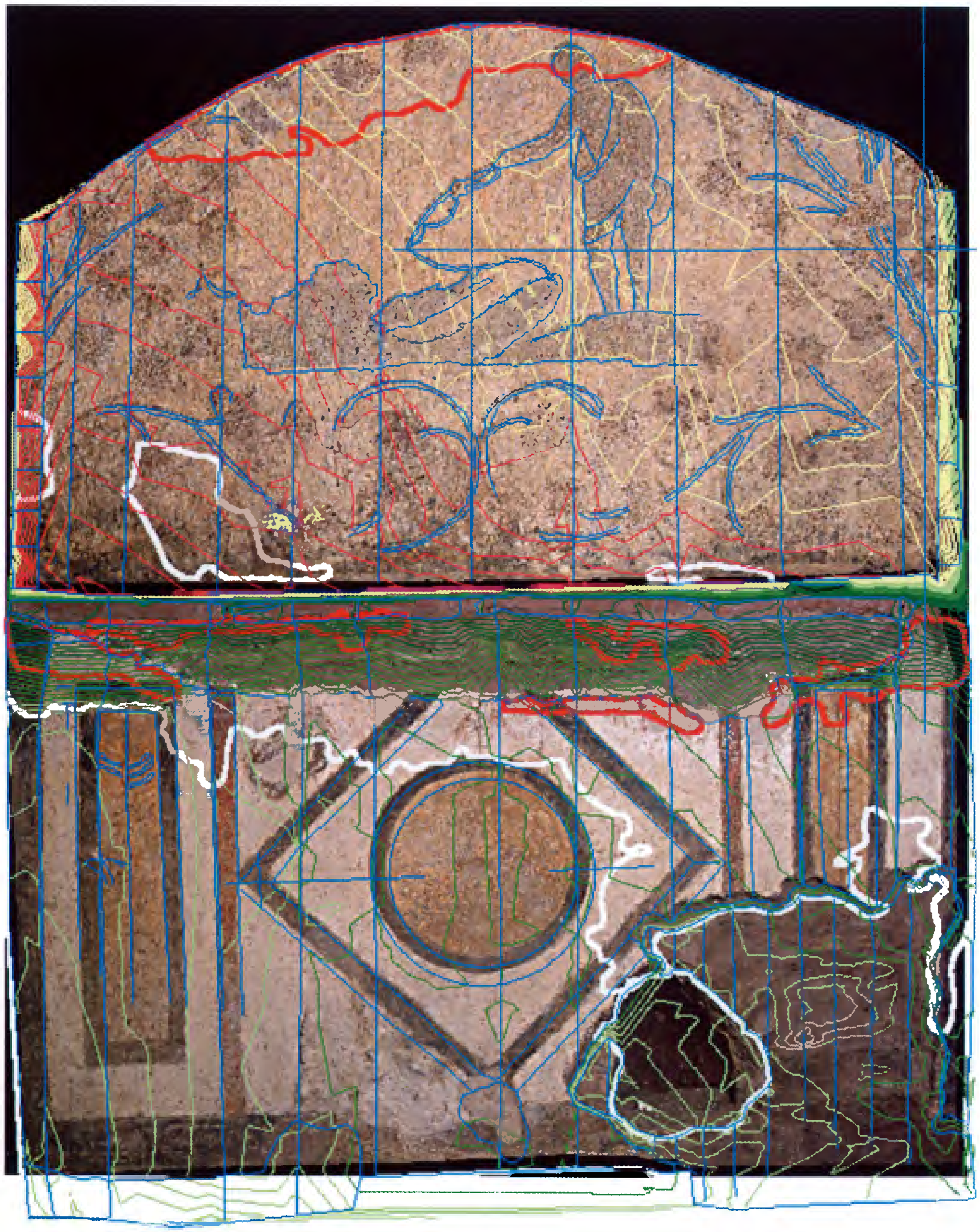

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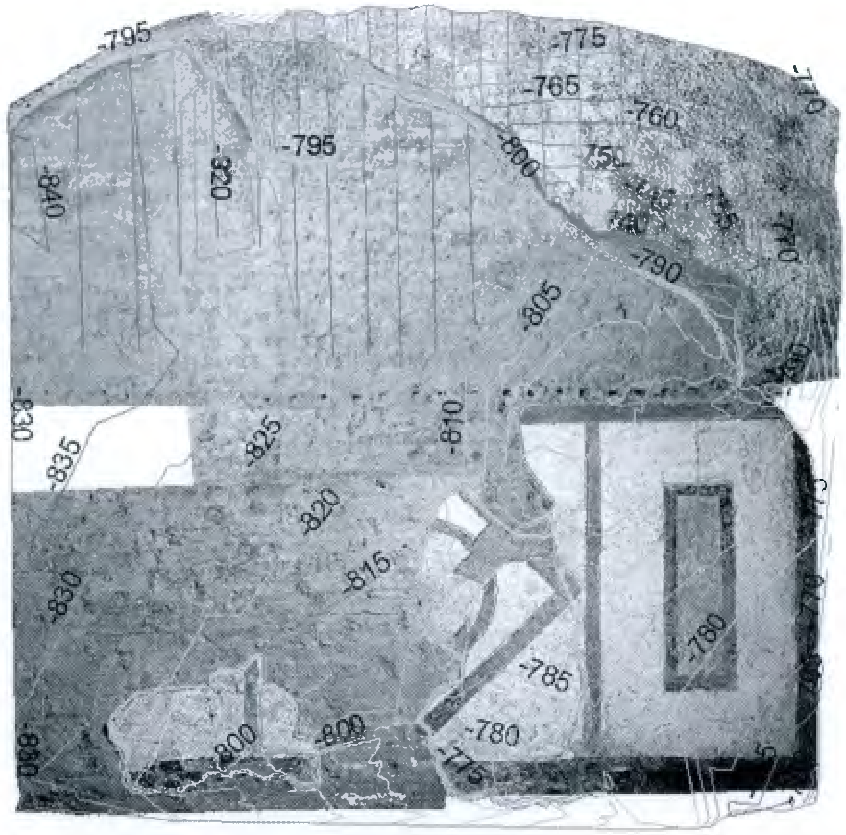

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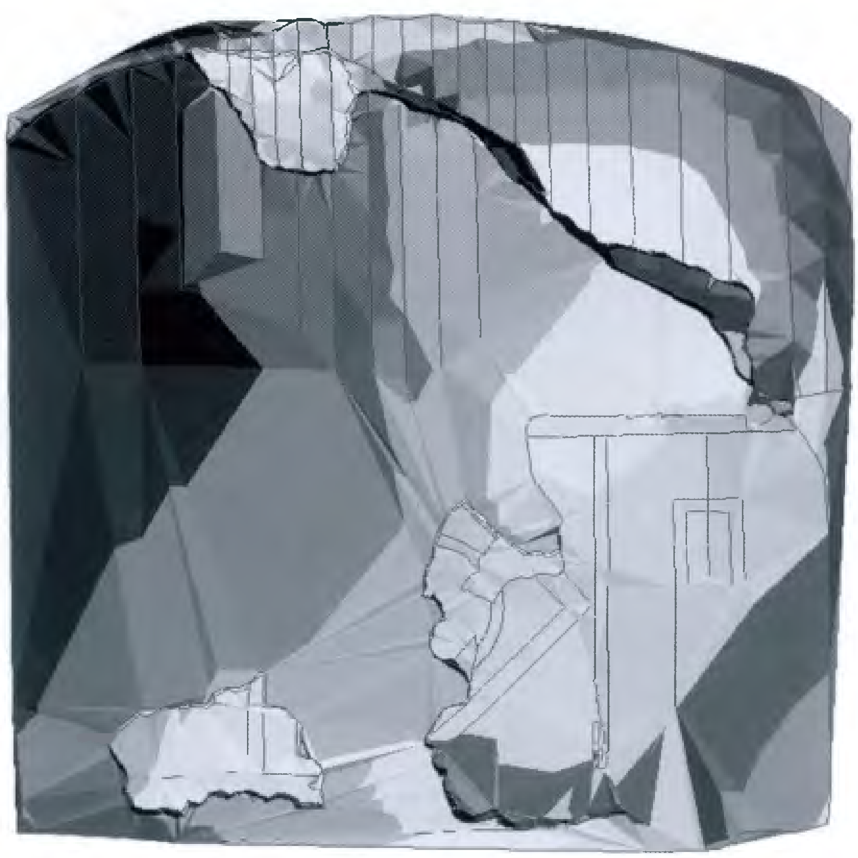

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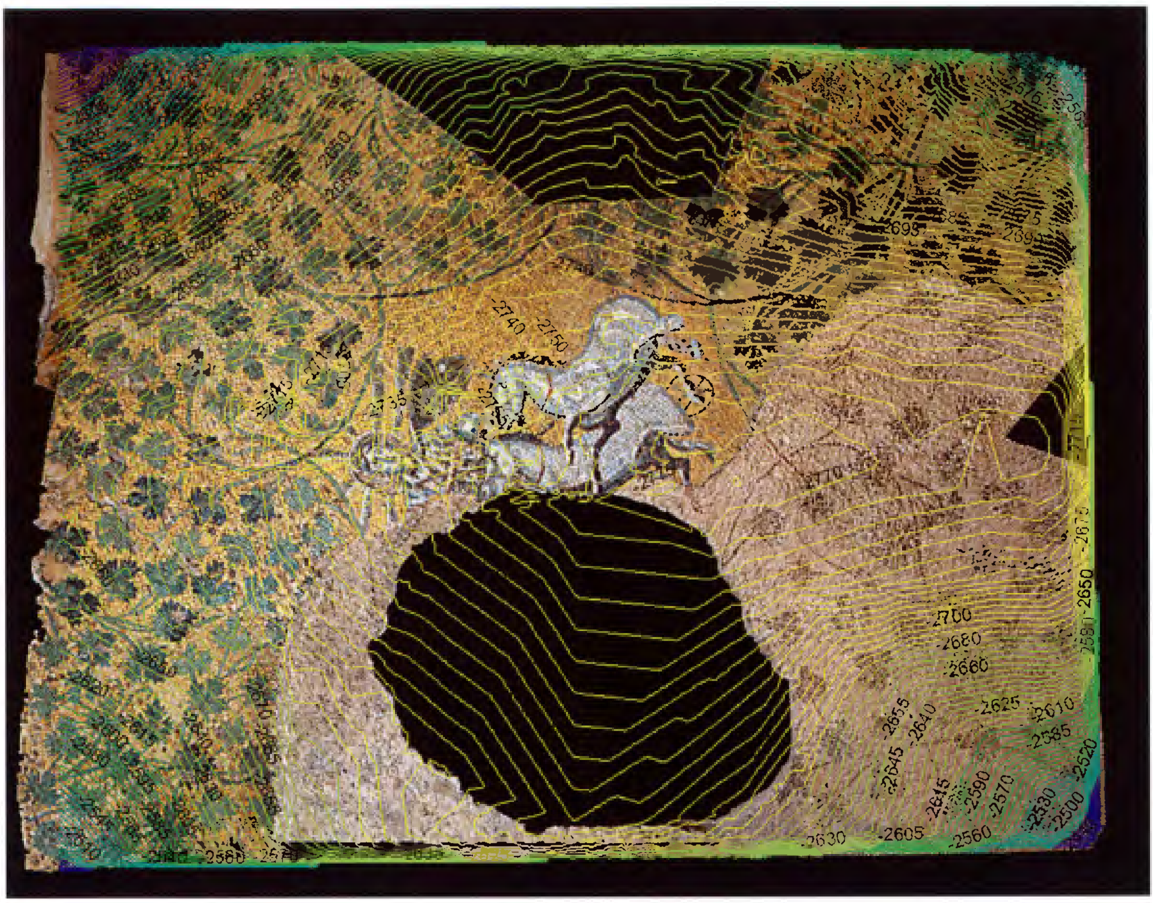

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Figure 17.

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LEVELS OF RECORDING AND DEMONSTRATION OF HERITAGE 3-D LASER SCANNING TECHNOLOGY FOR THE RECORDING AND MONITORING OF WALL PAINTINGS, MOSAICS AND OTHER CULTURAL RESOURCES

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ABSTRACT

"Heritage Recording" can be defined as the activity of accurately capturing information that describes the physical configuration, evolution and the condition of an object at known points in time. This activity should take place before, during and after interventions to an object. The more one knows about an object, the better it is understood, and consequently the more effective and efficient one should be in the conservation planning, decision making, management and monitoring processes.

This paper briefly outlines 'levels of recording' and provides conservationists with a framework of recording tools and technologies. It introduces and demonstrates 3-D laser scanning technology as a new state-of-the-art technology for the recording and monitoring of wall paintings, mosaics and other heritage objects. It briefly describes the technology and outlines some of its conservation applications through pilot case studies. Finally, it comments on its results with reference to other potential recording tools and technologies.

KEYWORDS: heritage recording; levels of recording; documentation; 3-D laser scanning; monitoring; presentation; interpretation; replication; repatriation of artworks; virtual reality.

INTRODUCTION

"Heritage Recording" can be defined as the activity of accurately capturing information that describes the physical configuration, evolution and the condition of an object at known points in time. This activity should take place before, during and after interventions to an object. The more one knows about an object, the better it is understood, and consequently the more effective and efficient one should be in the conservation planning, decision making, management and monitoring processes.

This paper begins with definitions pertaining to 'heritage recording' terminology developed over the past ten years in consultation with experts from ICCROM, ICOMOS, UNESCO and CIPA.

These definitions were presented in a first manuscript entitled *Recording, Documentation and Information Management Guidelines for World Cultural Heritage Sites,* prepared by the author at the request of ICCROM to complement the *Management Guidelines for World Cultural Heritage Sites (*Feilden and Jokilehto, 1993). The manuscript was circulated in 1994-5 to over 120 conservation institutions and documentation experts worldwide for review and comments. It is expected to be finalized and published shortly. The definitions were initially requested by ICCROM to facilitate dialogue among conservationists discussing heritage recording needs, optional tools and their applications. In addition, at the request of ICOMOS, a workshop was organized by CIPA and took place at ICCROM to review and refine the document on *Recording Principles* proposed by ICOMOS-UK and ICOMOS France. The resulting document – *ICOMOS Principles for the Recording of Monuments, Groups of Buildings and Sites* – was ratified during the ICOMOS General Assembly in Sofia in 1996 (ICOMOS-CIPA *ad hoc* Working Group, 1996).

The paper also provides conservationists with a generic listing of the traditional and digital recording tools and technologies that are currently used in conservation practices. This listing is felt necessary to provide non-recorders with an understanding of what recording tools exist and how they can complement each other. The listing is presented in Matrix Guideline tables, divided into Levels of Recording, that are described later in this paper. These Levels of Recording are directly related to the conservation process also described in the manuscript and guidelines mentioned above. They are outlined in this paper to suggest how heritage recording activities can be integrated cost effectively into the conservation process.

The main purpose of this paper, however, is to demonstrate 3-D laser scanning technology as a promising new tool that should be attractive to conservationists when very accurate, three-dimensional information is required. A quick overview is provided of 3-D laser scanning pilot projects that were initiated by the author in 1995 and undertaken with the Israel Antiquities Authority (IAA) and National Research Council of Canada (NRC), in Israel, in 1996. Most of the project results presented hereafter are from the Israel Scanning Pilot Projects compiled by NRC (Domey *et al.,* 1998).

Referring to the Matrix Guidelines and Levels of Recording below, 3-D laser scanning technology would generally be applied during the *Detailed Recording* phase of the conservation process.

DEFINITIONS

Heritage Recording. The graphic capture of information relevant to understanding the physical configuration, evolution and condition of a heritage resource, at known points in time, and the basis of decisions made to alter or care for such resource.

Documentation. Information units acquired over time through recording and other research means and constituting the knowledge base for particular heritage resources.

Information management. The process of acquiring, storing and sharing resource documentation to ensure its accessibility, security and reliability.

Conservation. Concerned with the transmission of cultural heritage, with its significant messages intact and accessible to the greatest degree possible.

Conservationists (conservation specialists). Those individuals who, whatever their initial profession, trade or discipline, engage in the practice of conservation and are committed in their work to the application of the highest principles and standards of the field.

Conservation process. The analytical decision making process of ensuring that conservation intervention at all levels will respect the heritage values of sites while maintaining functional effectiveness within applicable budget and other constraints.

Research (and investigation). The process of acquiring information of all kinds pertinent to increasing knowledge of cultural heritage sites. Recording will be an essential component of research at each step and at each level of the conservation process.

Analysis. The interpretation of research results in order to improve understanding of cultural heritage sites and components.

Recorders (heritage recorders). Individuals expert in the design and execution of recording activities within the conservation process.

LEVELS OF HERITAGE RECORDING

The following sections are based substantially on the manuscript *Recording, Documentation and Information Management Guidelines for World Cultural Heritage Sites,* prepared by the author.

Three levels of recording may generally be considered:

- reconnaissance recording;
- preliminary recording; and
- detailed recording.

Each of these recording levels may be ***partial*** (i.e. tailored to specified needs), or ***complete.***

These levels are meant to be chosen and applied within the above-mentioned conservation process. The recommended progression in their use both ensures cost-effective recovery of optimum recording data essential for use at various project stages, and aids in effectively defining future recording requirements as work continues.

As projects progress, partial records will complement each other and eventually form complete and detailed site records. The accuracy of the information obtained varies with the choice of recording level. Tables A and B below illustrate the implications of the choice of various traditional and digital recording tools and technologies for level of recording.

Recording experience, judgement and initiative are essential requirements in ensuring effective application of appropriate technology to a given project or site.

The Reconnaissance Record Generally, the reconnaissance record is an overview photographic survey that will allow conservationists to visualize, in their entirety, a site and its related buildings and features in sufficient detail to understand the site's overall characteristics. It should permit rapid identification of significant features and problem areas. The quantity of photographs taken will vary with the size of the site and related structures and features, and the client's requirements. For a building, a reconnaissance record would normally include elevations, together with significant details. More complex sites – such as cultural landscapes or archaeological excavations – will require general views from all compass points and at various height elevations (i.e. heights of land), supplemented, as needs dictate, by representative details.

The Preliminary Record Preliminary recording will complement the reconnaissance record by providing more complete information pertaining to the most significant elements of a site. The purpose of this record is to produce a record of the resources' major features. Additionally, the preliminary record could include data necessary for preliminary analysis, and define areas for further investigation and future detailed recording. The accuracy of data should be approximately ± 10 cm for plans, elevations and cross-sections, and between ± 1 and ± 2 cm for structural and other details.

The Detailed Record Detailed recording may take place prior to, during or after a conservation activity, so as to record a site's physical configuration, condition and significant features. Detailed recording occurs when a highly significant resource becomes the subject of directed research and analysis, or intervention planning and conceptual design. To ensure cost-effective detailed recording, completeness should be tailored to the immediate needs of a conservation team. Detailed recording may be phased over a number of years, depending on planning requirements and related budget. The accuracy of a detailed record can vary between approximately ± 2 mm (for details) and ± 10 mm (for building plans).

Traditional heritage recording tools and techniques (Table A)

This Matrix Guideline provides an overview of traditional recording tools and methods generally used to graphically record a cultural heritage resource.

Digital heritage recording tools and technologies (Table B)

This Matrix Guideline lists the digital tools and technologies commonly used in heritage recording. Depending on the level of recording, these tools can range from low-cost personal computers and shareware, to workstations and sophisticated recording hardware and software.

Demonstration of heritage 3-D scanning applications in Israel

In October 1996, IAA, the author and the NRC undertook pilot projects to demonstrate the applications of one of NRC's 3-D imaging systems – a Large Field of View Laser Scanner – for heritage

Table A

Levels of recording / Characteristics	A Reconnaissance Record	B Preliminary Record	C Detailed Record
Purpose of recording	reconnaissance initial inventory initial planning reference data	planning initial condition investigation stabilization pre-design reference data	'as-found' condition design construction 'as-built' record maintenance/monitoring posterity
Recording Tools	35 mm photographs sketches	hand recording, large format photography 35 mm rectified photography 35 mm amateur camera stereo- photogrammetry	hand recording large format rectif. photography stereo-photogrammetry
Accuracy of drawings	not to scale	plans and elevations ± 5.0 in (± 10 cm) details ± 1.0 in (± 2 cm)	plans and elevations ± + 0.5 in (± 1 cm) details ± 0.1 in (± 2 mm)
Results	photographic report photo keyplan initial condition/description sketches	measured drawings asset description/condition observations photographic report	measured drawings assetdescription/condition observations photographic report
Cost (will vary in absolute terms with scale and complexity of site)	Low (a few days on site by recording team)	Moderate (several weeks or more on site by recording team)	Moderate to High (extensive and possibly ongoing activity on site by recording team)

Table B

Levels of recording / Results	A Reconnaissance Record	B Preliminary Record	C Detailed Record
1 CAD Heritage Records (vector)	CAD Drawings	Digitization of images CAD Database 3-D Modelling Rendering	Digital photogrammetry Analytical photogrammetry Reverse-perspect. analysis Total station surveys Visualization & rendering
2 Imaging (raster)	Photographs Digital images Video	Scanning Enhancement Rectification CAD overlay	Vectorization of images Orthophotography Image based GIS Laser scanning
3 Digital Reports (electronic)	text images drawings (low-cost electronic product)	text images drawings (electronic product)	text images drawings (desktop product)
4 Electronic Data Management and Distribution	Data acquisition Internet	Heritage records database Global positioning system (GPS) Internet	Heritage GIS Multimedia

recording in Israel. The system was used to scan the Tomb of St James in Jerusalem, the Holy Sepulchral Lintel in the Rockefeller Museum in Jerusalem, as well as several archaeological and architectural site features at Caesarea. Each site was used to demonstrate the use of the system for different heritage recording applications. The aim of the report was to illustrate the results for heritage and conservation professionals.

Ya'acov Schaffer and Gail Sussman of the IAA and Robin Letellier initiated this project in the summer of 1995, as a result of the Heritage Recording Training provided by Public Works and Government Services Canada.

[Additional information on each of the following descriptions / subjects is provided in the accompanying GraDoc demo CD].

Large Field of View Laser Scanner

The Large Field of View Laser Scanner is designed for high-resolution monochrome 3-D digitization of objects and large structures. For heritage recording applications, sculptures, architectural features and archaeological sites and their components can be recorded at a stand-off distance ranging from 0.5 to 10 m. At a stand-off of 50 cm, the resolution is 70 μm, and at 10 m it is 2 cm. The camera can be mounted either on a conventional photographic tripod or on a custom-designed telescoping tripod that can be raised to a height of 10 m. To record an entire object, sequential overlapping images are recorded from multiple points of view. Subsequently, the multiple-view datasets are merged or integrated into a seamless, archival-quality, high resolution 3-D digital model of the object, using POLYWORKS software. Once recorded, the software enables the archival 3-D model to be transferred into different formats and used for a variety of heritage recording applications.

Examples include:

- *Heritage conservation documentation* For heritage conservation practices, the system provides accurate and high resolution 3-D records of objects, artefacts, floor and wall mosaics, wall paintings, bas-relief, architectural features, etc., which can be used for conservation research, analysis, design and monitoring purposes, as well as for posterity records.
- *Replication* The data can be used to fabricate accurate 1:1 or scale replicas using modern replication technologies such as stereo-lithography or conventional machining. Exact replications are being carefully thought about as possible options for repatriation programmes.
- *Virtual reality theatre and interactive kiosk display* The data can be incorporated into programmes for virtual reality or virtual 3-D theatre applications, as well as for interactive kiosk displays. This type of virtual reality is currently being considered by UNESCO World Heritage Centre for purposes of presentation, education and entertainment.
- *Internet and CD display* The data can also be compressed for internet and CD display applications.

Laser scanner basic principles

The synchronized scanning geometry is based on a doubled-sided mirror that is used to project and detect a focused or collimated laser beam. The source used in the NRC system is a laser that is typically coupled to an optical fibre. The scanning mirror and a fixed mirror are used to project the laser beam on the scene. The scattered light is collected through the same scanning mirror used for the projection, and focused to a linear charge-coupled detection device (CCD). The CCD is tilted (Scheimpflug condition) to compensate for de-focusing at the detection. With careful optical design, the divergence of the laser beam can be made to match the resolving-element field-of-view of the CCD linear array. In such conditions, the parameters of the focused laser beam are kept constant over a large depth of view.

Israel project results

The following 3-D models data were obtained from St James' Tomb (Benè Hézir) in Jerusalem, the Holy Sepulchral Lintel in the Rockefeller Archaeological Museum, and several archaeological site features at Caesarea during four days of tests undertaken during the third week of October 1996.

The number of Figures in this paper have had to be limited due to publishing constraints. Should readers wish to see the additional 2-D and 3-D images from the project report, please contact: Letellier.R@ATTGlobal.net. Also, a '3-D laser scanning demo' should soon be available on CD from the author.

Site A – St James' Tomb (Benè Hézir)

The Arcosolia Room of St James' Tomb in Jerusalem measures approximately 2 m x 2 m x 1.8 m in height. It has been carved in the rock and the interior surfaces are rough and irregular in shape. Surfaces of this nature are very difficult to record accurately using conventional recording techniques. The objective was to digitize the entire interior of the room in high resolution. In addition, the data was used to prepare an interactive 3-D virtual reality theatre display of the room in actual size to demonstrate the application for 'virtual tours' of the site.

Recording work to scan the entire interior of the Arcosolia Room took approximately half a day, including considerable set-up time due to complications with a portable generator as power source. The 3-D model took a few days to compile.

Benefits of 3-D scanning are illustrated by the advantages of the scanner over other recording techniques, with the end result being a high-resolution 3-D image of the interior of the room, and one can use the data to produce very accurate 2-D orthographic images (Figure 2) and 3-D representations of any part of the room as needed (Figure 3). Additionally, cross-sections of any part of the room can be obtained horizontally or vertically by extracting them directly from the 3-D model.

To our knowledge, recording techniques currently used in heritage conservation practice (e.g. traditional survey methods, rectified photography, stereo-photogrammetry, distance meters, etc.) would be less efficient and could not provide the level of detail and accuracy achieved in this case. The ability of the software to produce orthographic (rectified photographic) images is unique in that orthographic projections of irregular wall surfaces cannot easily be achieved by any other means. This technology seems most effective for this site's recording needs.

Figure 1. Outside view of St James' Tomb (Benè Hézir).

Figure 2. Orthogonal projection of south elevation of Arcosolia Room.

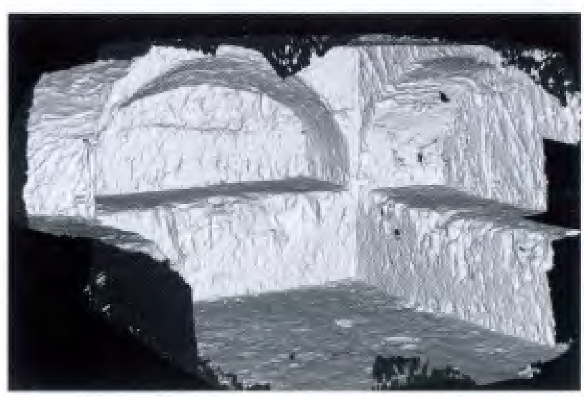

Figure 3. 3-D model in perspective view cut away (Arcosolia Room).

Site B - Holy Sepulchral Lintel, Rockefeller Archaeological Museum

The system was used to scan part of the Holy Sepulchral Lintel in the Rockefeller Archaeological Museum in Jerusalem. The aim was to produce a high-resolution 3-D digital model of the Lintel to provide a record that could be used (1) to fabricate either a 1:1 or a scaled model replica; (2) to produce a model which could be used for curatorial and historical

Figure 4. 3-D laser scanner in front of Holy Sepulchral Lintel.

Figure 5. Section of lintel that was scanned.

Figure 6. Scan (perspective view) of small portion of lintel.

research; and (3) to demonstrate the application for monitoring future decay or deterioration.

To record approximately 1 square metre of the lintel took about two hours, excluding equipment set-up time. To build the 3-D model took a few days.

The benefits of 3-D scanning are that one obtains a high resolution digital 3-D image of part of the lintel, and this data file can be used to drive a milling machine to carve into a variety of materials, reproducing the lintel full size (or scaled if desired) with an accuracy of up to a few hundred microns. An option could be to explore the use of stereo-lithography to produce a mould for replication of the lintel. One could also use the data to produce very accurate 3-D representations of any part of the lintel as needed (see Figures) The idea of 'virtually restoring' decayed objects for interpretation and presentation purposes has been suggested by conservationists working extensively with 3-D modelling and virtual reality software. 3-D laser scanning should expedite the creation of such virtual models.

Site C – Caesarea

Caesarea is one of Israel's more important archaeological sites. The scanner was taken to the site and used to scan several archaeological and architectural features.

C-1. Roman Mosaic Mosaic floor patterns are often difficult and time consuming to record accurately with conventional recording techniques. The scanner was used to document a section of a Roman floor mosaic to demonstrate the application of 3-D imaging to provide a database for analysing the pattern, documenting the current condition, and ongoing monitoring of the floor, as well as representing the floor surface in 2-D and 3-D.

Figure 7. Scanning of part of Roman mosaic.

Figure 8. Orthoprojection of Roman mosaic.

Figure 9. One scan (angle view) of the Roman mosaic.

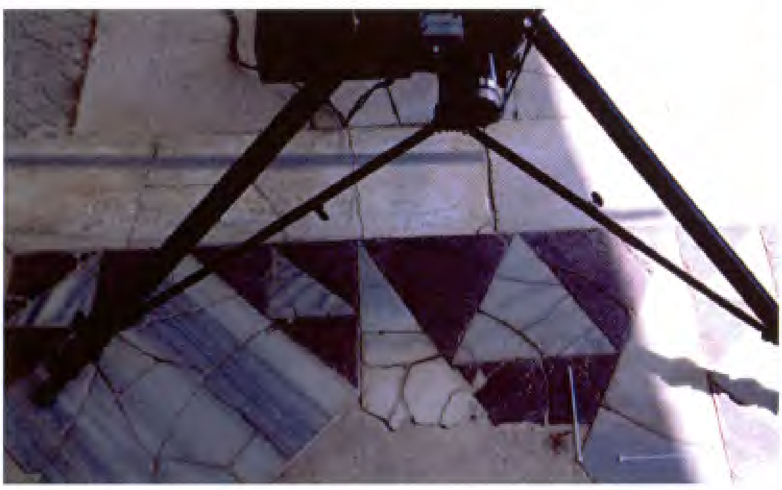

Figure 10. Scanning of part of marble mosaic.

Figure 11. Scan of marble mosaic.

Each individual recording scan of the Roman mosaic covered a surface of approximately 0.5 x 0.5 m. In this test (Figure 7), eight scans in all were taken, with an overlap between scans to allow for alignment of the images using POLYWORKS software.

One of the recording techniques generally used to record floor mosaics is rectified photography. When printed to scale, rectified photographs can be traced over to produce a line drawing of the floor details. 3-D scans of a floor mosaic can be used to achieve the same results with greater accuracy, and with the added value that the information provides a 3-D metric representation of the floor surface. This very accurate 3-D representation provides condition data that is not easily visible in 2-D. Algorithms can be written to delineate edges of well-defined pieces of mosaic. These algorithms can significantly reduce the labour in production of a 2-D (vector) condition database of the floor mosaic.

C-2. Marble Mosaic It can be tedious to record the irregular shapes of marble mosaics using conventional recording techniques. Using the image data from 3-D scans, the boundaries of the individual marble tiles as well as the cracks can be examined in detail.

C-3. Byzantine Mosaics The purpose of this scan was to document a Byzantine floor mosaic that was in poor condition. The data provides a 3-D record that can be used to assist in assessing the condition of the floor as well as to monitor ongoing deterioration with time.

The benefits of 3-D scanning are that there are few recording techniques on the market that allow one to quickly and accurately record in 3-D the fine detail and condition of such badly damaged floor mosaics. Using virtual reality techniques, one could rotate the 3-D images to view and study the model from different points of view.

Deterioration of the floor can be measured over time by re-scanning the same surface at a later date and by digitally comparing the two scanned surfaces. Such a level of accuracy in monitoring is difficult to obtain using other recording techniques. Cross-sections of decayed areas can easily be produced from the 3-D model.

C-4. Hippodrome Fresco The surface condition of frescos and wall paintings is also often difficult, as well as time consuming, to document in detail using conventional recording techniques. In this recording, 6 m^2 of fresco at the Hippodrome was scanned to illustrate the applications of 3-D imaging for this type of documentation.

In most cases, when frescos are uncovered, they must be recorded without delay so as to accurately capture all information on the wall surface (i.e. relief, colour(s) and the delineation of all details) before the surface deteriorates. This recording is generally done by sketching the surface detail to scale and providing photographic records that show the paintings, their colour(s) and condition. The results generally consist of a 2-D graphic representation of the fresco, with an accuracy of 5 mm.

For this project, the scanning took close to half a day of field work in direct sunlight conditions. Approximately one day of image compilation was required to produce the results shown in Figure 16. The accuracy of these 3-D images is to within a few hundred microns.

In the office, the field digital data was translated to DXF format (for use with AutoCAD) for conservationists to view images on their personal computers. These DXF files can be used by anthropologists and archaeologists as baseline data (or working drawings) for planning purposes and for reporting their findings.

A significant benefit is that the scanner can somewhat be considered an "on-line stereophotogrammetric system" that provides instant (without plotting) high resolution scaled and rectified images (accurate to a few hundred microns), and 3-D representation (in relief) of the wall surface. These images can be used as orthophotos for condition and decay analysis

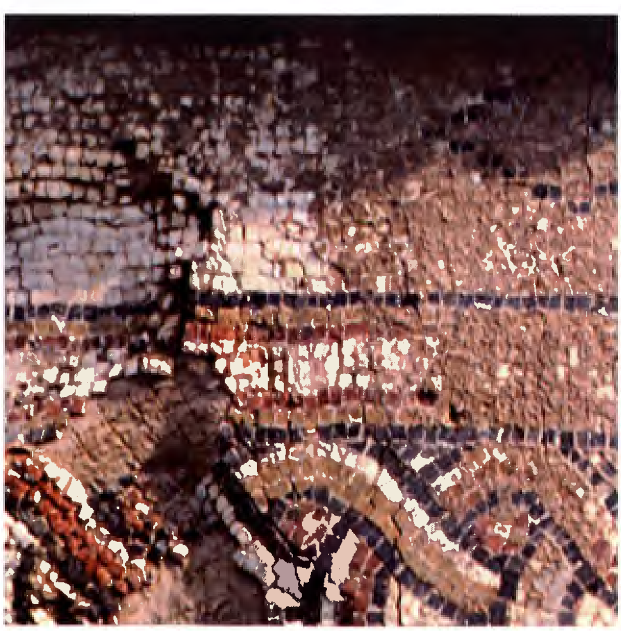

Figure 12. Photograph of damaged part of the Byzantine mosaic.

Figure 13. Scan (perspective view) of part of the Byzantine mosaic.

Figure 14. Photograph of Hippodrome wall painting.

Figure 15. Scan (orthoprojection) of damaged wall.

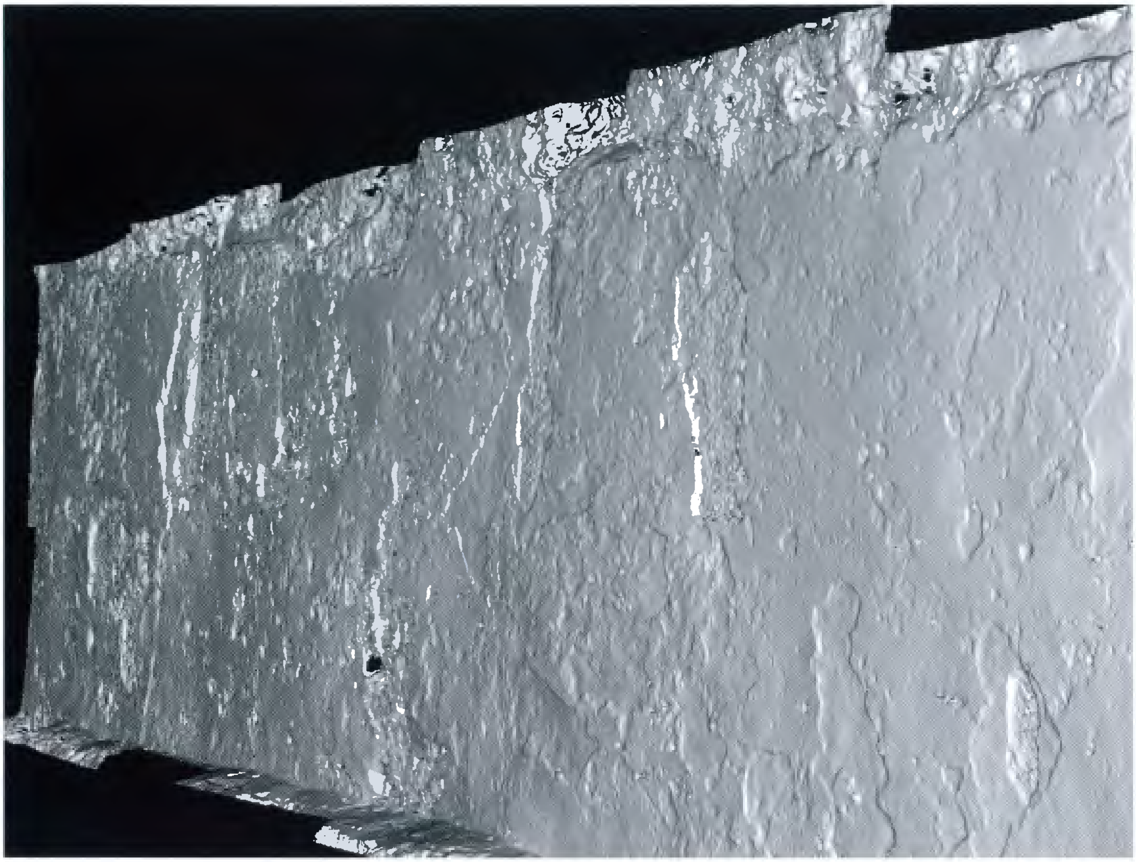

Figure 16. Scans of hippodrome wall at angle.

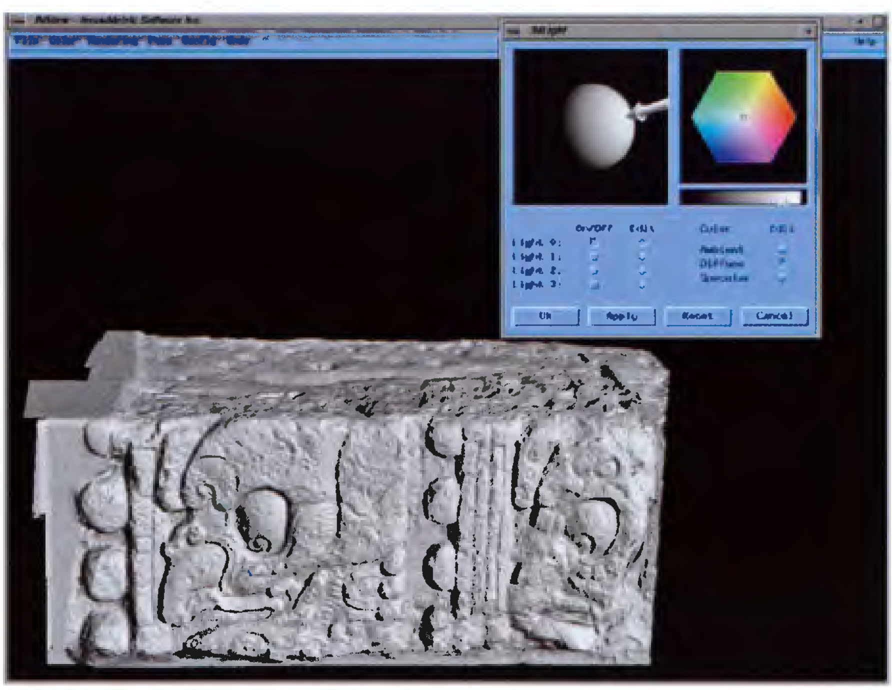

Figure 19. Software raking-light feature used to enhance Maya writing on stone surface.

(Figure 15), and be traced over electronically (with CAD overlay software) to provide a vectoral delineation of the decayed areas or of the mural paintings that are visible on the scanned image. POLYWORKS software includes a 'raking-light' feature that permits enhancement of surface data for purposes of analysis. Figure 19 is borrowed from the Peabody Museum Scanning and Replica Project (Letellier, 1998) to illustrate how raking light was used in enhancing Maya writing found on stone surfaces.

Monitoring of deterioration of the wall surface can be measured over time by re-scanning the same surface at a later date. As the software can measure the surface differentiation between the two scans, it can identify the changes by colour code, thus showing areas that have decayed since the first scan. To our knowledge, such accurate 3-D monitoring (i.e. very accurate measure of change) cannot be obtained as effectively by other known recording techniques.

C-5. Byzantine Lion-Head-Gargoyle: A lion head gargoyle was scanned to illustrate how quickly and accurately the scanner can be used to record a typical architectural feature containing complex shape and detail.

In archaeological conservation practice, all significant artefacts should be recorded in detail for the purposes of research, analysis, conservation, monitoring and posterity. Complex objects are generally recorded with measuring tapes, plumb bobs, profile gauges and photography. In most cases, the results contain 2-D line drawings with accompanying photographs and annotations. The Byzantine lion-head gargoyle shown here is one of many artefacts located in Caesarea. Due to time limitations, only a few scans of the gargoyle were taken, to demonstrate the technology.

In this case, the field scanning took less than 30 minutes to record the front and part of one side of the gargoyle. To scan the entire gargoyle could require approximately one hour or so, or between 10 and 15 scans. To compile the digital data into a final 3-D model could take up to a day or so.

The benefits of 3-D scanning are that, by viewing the images, one can appreciate the possibilities of analysing an object from all sides

Figure 17. Byzantine Lion Head Gargoyle being scanned.

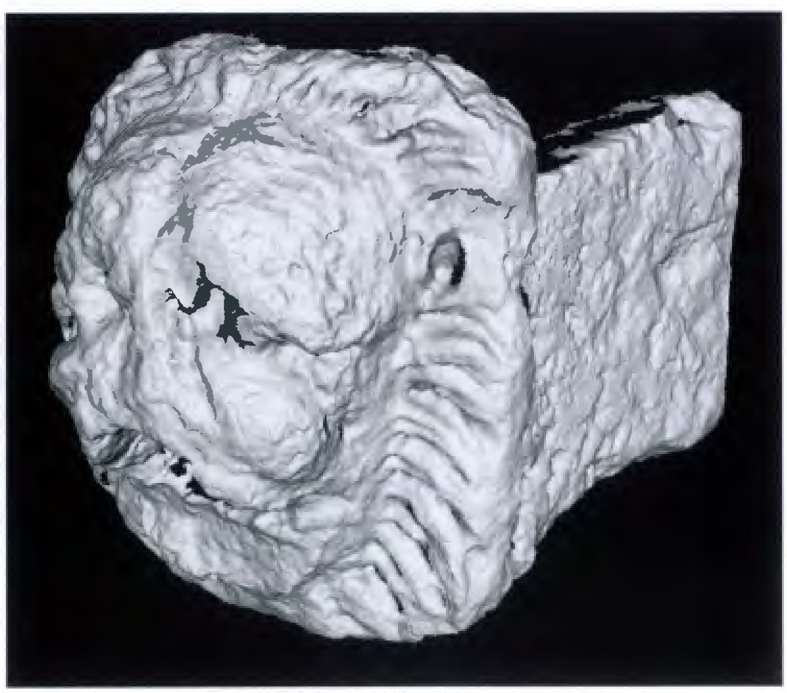

Figure 18. Scan (angle view) of Lion Head.

Figure 20. Sculpture enlarged x 2.5 using laser scanning data to drive a milling machine (Heritage 3D).

Figure 21. Leg of sculpture being carved by a milling machine at x 2.5 original size.

Figure 22. Resulting enlargement displayed in main entrance of office building.

using a 3-D viewer. The high resolution 3-D images also allow for accurate analysis of surface details and decay.

As indicated in some of the other trials outlined above, horizontal and vertical cross-sections and profiles of any part of the object can easily be obtained from the 3-D model, with an accuracy of approximately 100 µm. Contour lines that are often generated by stereo-photogrammetry can also be extracted directly from the 3-D model. Should a replica be needed (at any scale), milling machines and stereo-lithography are available to produce accurate copies. Figures 20 and 21 illustrate a x 2.5 enlargement of a sculpture produced from 3-D laser scanning data driving a milling machine.

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22

THE STEREOSCOPIC EXPLORATION OF 3-D MODELS AS INSTRUMENTS OF KNOWLEDGE, DOCUMENTATION AND MEASUREMENT FOR MURAL PAINTING

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ABSTRACT

New digital technologies are important contributors to the study and documentation of mural paintings. The StereoSpace system offers the possibility – even to inexpert operators – of examining a subject directly through stereoscopic visualization. The method is easy and comfortable and allows continuous stereoscopic exploration of a model built from a stereopair block. It is made possible by the use of special eyeglasses and electronic screens applied to a traditional PC. StereoSpace permits one to seamlessly cross the boundary between two adjacent models.
The main features of the software are that it can:

- simultaneously combine 3-D, geometric and thematic features at every point;
- perform data collection;
- make 3-D measurements, such as length, positions, distances, areas or volumes;
- place one in stereoscopic preliminary maps;
- display more than one stereoscopic model at the same time, for example, from different periods or produced using different techniques (e.g. IR, UV, etc.); and
- provide almost unlimited possibility of using a model again in relation to a second model.

KEYWORDS*: digital photogrammetry; stereoscopic view; 3-D model; 3-D measurement; 3-D digital exploration.*

INTRODUCTION

Menci Software is an Italian company that designed and produces the digital photogrammetric workstation: *StereoView (SV)*. The system is structured in several modules, each one simply related to the other, allowing one to manage the entire photogrammetric process from inner orientation to three-dimensional (3-D) plotting. The principal software components are the *SV ImageBuilder*, which facilitates inner orientation of the photograms, *SV Orientation* and *SV Triangulation*, which allow one to do external orientation, and *SV Plotter*, created specifically for 3-D restitution. The system presented here is another StereoView module called *StereoSpace*. All products are distributed by *Nikon Instruments*.

The *StereoSpace* system is a digital stereoscopic navigator for documentation, 3-D representation and measurement of cultural and artistic heritage. It is based on a capacity to continuously manage more than one photogrammetric model, previously oriented. As described during the GraDoc seminar, "it is, in brief, a 3-D metric photograph which reproduces the whole object observed, or, in other words, a 3-D photographic model that can be measured and on which it is possible to draw in space." To explore the potential of this model, it has been tested on the *Fountain of the Four Rivers* by Gian Lorenzo Bernini – a combination of sculpture and architecture that is very difficult or quite impossible to measure and represent with traditional techniques.

THE STEREOPHOTOMAP

The basis of the software design is the idea of the *StereoPhotoMap*. The name itself already explains the main concept: *Stereo* because it makes use of stereoscopic viewing, *Photo* because it is composed of digitized photograms; and *Map* for the metric properties that it contains.

We can consider the traditional descriptive cartographic representation as a simplification of the information present in the stereomodel, well known to the plotter cartographer. In fact, when tracing an entity following the 3-D outlines in the stereoscopic image observed in the instrument, a certain amount of interpretation must inevitably occur.

Through photogrammetric restitution, the model loses the feature of 'real' to become a representation. The subjective interpretation, even if fixed by standard criteria, takes the place of the *measurable reality* that the stereoplotter presents to the operator's eyes.

The main aim is to convey the utility of the stereomodel from the instrument to the end user, avoiding the traditional passage through drawing representation. The main job of the plotter cartographer will be to describe the typological aspect rather than the morphological one, creating the basis for data that are suitable for management through a territorial or architectural information system. Extremely complex and expensive traditional representations, such as contour maps, lose out in a descriptive sense to the advantage of the possibility of enriching the map with typological content.

PECULIARITIES OF THE STEREOPHOTOMAP

The *StereoPhotoMap* concept goes beyond the limits posed by stereopairs. If stereoscopic image making is subordinate to the stereopairs used, where stereopairs are two adjacent photograms properly taken with about a 60% overlap, in order to provide a stereoscopic view in the common part of the two photograms, it is also true that the 3-D exploration of the model can stimulate interest in extending navigation to adjacent models. The observer is caught up in stereoscopic navigation, and passes through the space without noticing the photograms' limit line, because the exploration movement is fluid and transparent. During stereoscopic exploration, taking of measurements, tracing polylines or any other function allowed, the selection and loading of photograms are completely automatic.

We can consider the photogrammetric block as a unique, continuous stereomodel in which the single photogram increases its informational content due to the close analytical link that ties it to the other elements of the block.

Another feature of *StereoPhotoMap* is that it can be dimensionally consulted and thus one can obtain 3-D metric information – positions, distances, areas and so on. The last main *StereoPhotoMap* characteristic derives from its capability to manage stereoscopic visualization directly at the photograph level. Clearly, there is vast potential for informative content in the stereoscopic photographic model.

STEREOPHOTOMAP – DCM

The foregoing is implemented by a 3-D navigation software suite called Digital Continuous Model (DCM), specifically produced by Menci software and distributed internationally by Nikon Instruments. It is developed for cultural heritage applications and has specific functions of viewing and interpretation that are characteristic for close-range photogrammetry. This software extends the concept of the *StereoPhotoMap* or DCM and has structured them in an easy and efficient interface implemented using Windows NT.

The objectives were:

- speed in loading and viewing high-resolution images;
- multidocument management able to simultaneously view stereoscopically more than one model; and
- integrated with Windows NT.

The resulting characteristics are:

- Data Tree View Management;
- dynamic navigation of stereoscopic models;
- simultaneous viewing of several stereoscopic models;
- possibility for 3-D measurement;
- automatic selection and loading of stereopairs;
- simultaneous stereoscopic comparison between several models; and
- a drawing window.

It is possible to carry out 3-D mapping of phenomena observed on the object by simply drawing lines on the model. For instance, an exact map of the condition of the object can be produced very quickly. This is an important feature for conservation specialists, providing them quickly with a precise plan before starting the conservation phase.

FIELDS OF APPLICATION

There are numerous fields of application where the *StereoPhotoMap* is a valuable tool for comprehension and documentation of objects under examination. The fact that the photographic operation and the topographic survey represent just a small part of the total cost required for producing a measured drawing, suggests the use of *StereoPhotoMap* in all situations in which it is necessary to document the condition of an object over time. Taking the photograms and orienting them is enough to create an archival document of the object's condition at any given time, without further elaboration. DCM, through the contemporaneous consultation of several stereoscopic models, permits 3-D comparison between different situations. The *StereoPhotoMap* in fact is a stereo plotting facility that is always potentially ready to provide the 3-D information requested by the observer.

Apart from following chronological evolution, DCM allows comparison between models realized with different photographic techniques (visible, IR, UV) or between models at different scales.

The main fields of application are:

- DCM:
  - cultural heritage conservation;
  - architecture; and
  - archaeology.
- StereoSpace:
  - cartography;
  - geology;
  - town planning;
  - agronomy; and
  - forestry.

SPECIFIC APPLICATION TO MURAL PAINTINGS

The examples presented here are applications realized with the digital stereoscopic navigation system on two architectural subjects and particularly on documentary photograms of mural paintings.

The first case is the stereomodel of the vaulted roof of the main nave of the *Lower Basilica of St Francis* in Assisi, Italy.[1] Photograms were taken after the calamitous earthquake in September 1997, and the damaged zones are clearly visible. The instrument allows one to analyse directly – live – every single detail of the model.

The stereoscopic navigation, in fact, allows one to reach every area of interest and to take measurements and produce maps as well as perform diagnostic analysis and evaluate the condition of the object. The possibility of loading different details and viewing them contemporaneously is of great help in the study and comparative analysis of the structure and its decay. The stereomodel consists of 14 photograms oriented longitudinally on the vault of the entire nave.

The second case consists of the stereomodel of the cupola of the *Church of Purgatory* in Terracina (Latina, Italy). The survey was performed by Architect Paolo Salonia of CNR, ITABC-Montelibretti (Rome). The stereomodel consists of 27 photograms with a great overlap (more than 80%). The frescoed surface is less interesting from an artistic point of view than the preceding case, but no less significant as an application example for evaluation and study of decay. The instrument is suitable in a precise and efficient way for the evaluation of the extent of cracking and for diagnostic analysis of decay.

The conservator, the architect, the art historian, or anyone interested in an in-depth knowledge of a mural painting can easily carry out research with a simple and efficient instrument.

TEST ON THE CUPOLA OF THE CHURCH OF PURGATORY IN TERRACINA: THE 3-D GEOMETRIC MODEL AND THE STEREOSCOPIC VECTOR/RASTER INTEGRATION

Introduction

The principal concept on which this example is based is the conviction that technologies and methodologies developed to solve questions at a territorial scale are valid instruments for a cognitive approach, scientifically rigorous, even at the scale of buildings and thus for a great variety of immovable cultural heritage. In fact there is a complete analogy between the two different situations. In both cases we have realities characterized by their own measurable physical dimension and by specific phenomenological peculiarities that can be described.

On that basis, one has to consider what is the cognitive process implicit in the different outcomes for different professional fields (often interrelated) such as history of art, architecture, study of decay pathology or conservation planning.

This process is based, in a first phase, on metric survey operations, with the characterization of different descriptive typologies (history, materials, nature of decay) and the creation of the base map onto which to elaborate further analysis and thematic maps. The second phase should have a visualization and data managing system in which one can reconstruct the reality in a very flexible way, in order to be useful to the different end users.

The commonly used, almost standard, procedure consists of a graphic restitution of the image contents, through digital stereoplotting, with control points topographically defined by orthogonal *x*, *y* and *z* coordinates. By its very nature, such restitution involves subjective interpretation, implying an information loss (or at least an alteration of it): from 'real' it becomes an abstraction (i.e. a synthesized line drawing).

A photograph, in contrast, has a complete informative content totally corresponding to reality in both the quantitative-dimensional aspect (geometrical) and the qualitative-phenomenological aspect (descriptive).

As a consequence, the goal became the creation of a system where the end user has a photographic image that is geometrically correct, onto which can be superimposed various functions of analysis, interpretation and planning, avoiding the graphic transfer process.

Testing in the field

Trials were conducted on the dome of the Church of the Purgatory in Terracina, a building in the upper part of the town, on the site of a more ancient nucleus of the 13th century. Large-scale re-arrangements in the 13th century transformed the church inside and outside, as can be seen today.

The main feature of the monument is the dome-cap, built on concentric corbels and resting on a drum that is the same cylindrical shape as the church's interior, which has a central plan.

The internal surface of the dome is tempera painted in 13th-century style. It represents subjects related to the church's name. The painted vault is not of particular interest, either for its artistic values or for its construction techniques or for the decay patterns that can be observed at present. Through the metric survey, data was obtained that enabled development of both a geometrical 3-D model of the dome and a stereoscopic photographic model of the painted surface.

The aim was to realize a vector-raster integration between the 3-D model and the stereoscopic photographic model within 3-D navigation software that would allow different types of users to manage analysis and interpretation through use of the stereomodel.

The acquisition phase

The cupola has a circumference of 13 m and rises about 7 m above the impost height.

The work phases were:

- Data acquisition for the 3-D geometric model:
- positioning the topographic instrument (in this case a Leica DISTO LASER, interfaced with a total-station Pentax), approximately at the centre of the church (instrument height 1.483 m, distance from the central part of the

dome's interior surface 15.938 m), a total of 874 points (*x, y, z*) on 16 vertical sections of the vault (16 semi-circumferences) were taken; and

- then 1211 points were taken (*x, y, z*) on 16 horizontal sections of the vault (16 circumferences).
- Data acquisition for the stereoscopic photographic model:
- positioning the camera (ROLLEI 6006, 66 semimetric, lens 80 mm, Kodak Professional film 120 ASA) in a zenithal orientation to the vault (by means of a board laid on tripods and controlled with a water level), 5 photographic strips of the vault were taken, from one side of the church to the other. The first strip has three images, the second, third and fourth have seven images each, the fifth again has three images; in total 27 photograms which cover the entire surface with an overlap of around 80%; and
- positioning the topographic instrument (Leica DISTO LASER connected to a Pentax station) in the centre of the church, a total of 45 control points were taken (*x, y, z*) distributed on the mural painting.

Elaboration of the digital continuous model

In the data processing phase, the 27 photograms were scanned with an Epson GT 12000 scanner at 1000 dpi resolution.

- Restitution of the 3-D geometric model with:
- Topographic survey
- Contour lines
- Contour line map
- Digital Elevation Model (DEM)
- Triangular Irregular Network (TIN)
- Integration of the two models vector/raster
- Realized with Menci Software's *StereoView*.
- Realization of the stereoscopic photographic model using Menci Software's *StereoSpace*.[2]

The data elaboration related to the Lower Basilica of St Francis in Assisi involved:

- 3-D Raster Model
- 3-D Raster Model with vector superimposition
- Orthophoto of the vault of the nave
- Orthophoto details

Technical elaboration was performed by Menci Software.

EVALUATION AND COMPARISON OF DCM/STEREOSPACE DIGITAL DOCUMENTATION AND TRADITIONAL METHODS

The advantages of a digital documentation system can be summarized as follows:

- Possibility of having the entire 'real' model.
- Coordinates of the point are always visible.
- Diagnostic evaluation and metric information simply and quickly available.
- Data permanency (support cannot deteriorate).
- Measurement tables can be exported to an Excel spreadsheet.
- Parallel comparison between different areas and different decay situations.
- Comparison of the same object as a chronological series based on models created at different times.
- Parallel comparison of different models.
- Comfortable and relaxing stereoscopic viewing.
- More than one user can consult the same model contemporaneously (with special spectacles).
- Investigations on the PC monitor rather than *in situ.*
- Possibility of zooming into the stereo model.
- Thematic maps and elementary entities exportable into other digital formats.
- Simple maps can be drawn on the stereo model.
- Easy system and friendly interface.

SYSTEM STRUCTURE

The DCM software represents a server-client system. The server consists of the complete set of data that can be transferred using movable support (CD-ROM or DVD) to a computer working in a local network or by using simplified models on a remote net (via Internet or dedicated net). This set of data consists basically of correctly archived stereoscopic models and is normally produced by photogrammetric operators with a thorough knowledge of stereopair orientation technique in both independent models or in aero-triangulation.

The client is the DCM station, with an easy stereoscopic viewing system that allows everyone to use it. In fact, no particular preparation is required to use the system.

Data production

Usually the data producer is a company specialized in cartographic data production, using a client station to check data prepared for the server.

After having taken the photograms and completed the topographical survey, the work phases specific for DCM are described below:

Digitization of photograms

This phase needs to be done with special care because this is the basis for the model's visual quality and its metric precision.

The use of a photogrammetric scanner is preferred; when this is impossible, it is indispensable to carry out geometric distortion correction (for example, using *SV Scan*). The resolution of the acquisition depends on the intended use of the data, whether for documentary, thematic, archival or mainly metric purposes. Resolution also depends on the dimension of the original images. There is no limit to using large images. Normally one works with a resolution between 600 and 4000 dpi. Images are archived in raster cryptographic format or in TIFF standard.

Orientation of the models

Specific orientation software (*SV Triangulation*) is used. The block orientation guarantees model continuity through the photogram series, avoiding the danger of interruptions that can compromise the effective use of the stereograms and the precision of measurements. It is possible to use many oriented stereopairs. The orientation of single photograms is indexed and managed in a database that contains all the necessary parameters to describe the external orientation. This is what is generally known as a photogrammetric block, and it is clear that the process that leads to its creation is the standard production process for a photogrammetric map, related to the main phase of topography – capture and orientation of photograms.

It should be emphasized that it is possible to re-use all the data of work done with traditional photogrammetric techniques, if well archived, even though it is advisable and more coherent to plan for an eventual production process developed entirely with digital techniques.

Hardware system

The entire system, both the preparation software and the DCM consultation software, is designed and produced specifically for Windows NT.

The base hardware requirement is a Pentium II with 128 or 256 Mbytes of RAM, with a *stereo-ready* graphic board. The stereoscopic viewing is effected using LCD spectacles (active) or with a polarizing screen and passive spectacles.

The stereoscopic viewing experience is comfortable, relaxed and safe, thanks to the high refresh frequency used (more than 100 Hz). It is always advisable to use a good-quality monitor.

CONCLUSION

The *StereoPhotoMap* and associated DCM represent respectively an idea and an advanced technology in the production and management of numeric cartography. The main goal reached is simplicity and immediacy of consultation.

With this instrument one has a '3-D mouse' to navigate, measure and document the space that surrounds us. The integration of this user-friendly technology with sophisticated territorial or architectural information systems represents a very efficient marriage of data production and data consultation capable of ever-expanding implementations.

1. The stereophotogrammetric survey was done by FO.A.R.T. s.r.l. of Parma, for the Ministero per i Beni Culturali e Ambientali-Soprintendenza per i Beni AA.SS dell'Umbria, with Professor A. Paolucci as Commissario Straordinario and Ing. L. Marchetti as Vice-Commissario.
2. The architectural survey was coordinated by Arch. Paolo Salonia, and realized by Ms Federica Cappelli, graduating in Architecture at Rome University – 'La Sapienza', by Geom. Mario Mascellani and by Sig. Gaetano Pappalardo, of the Istituto per le Tecnologie Applicate ai Beni Culturali del CNR.

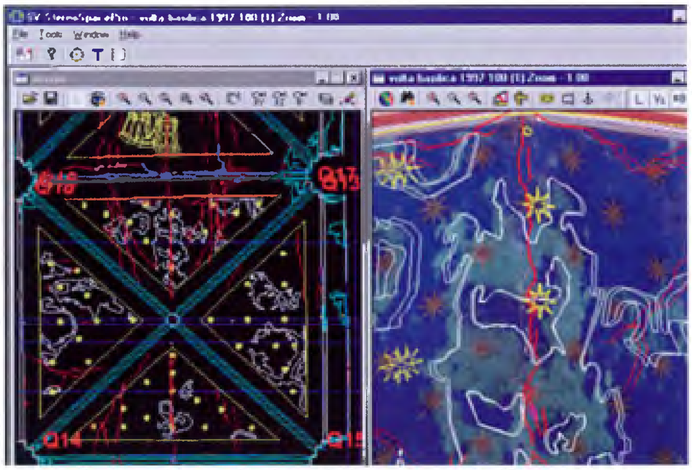

Figure 1. StereoSpace system: on the left is a CAD window with an imported *.dxf and on the right the corresponding stereo frame. You can see the drawing on the raster thanks to a special function of vector superimposition. The subject is the vault of the upper basilica of Assisi. Data from FOART.

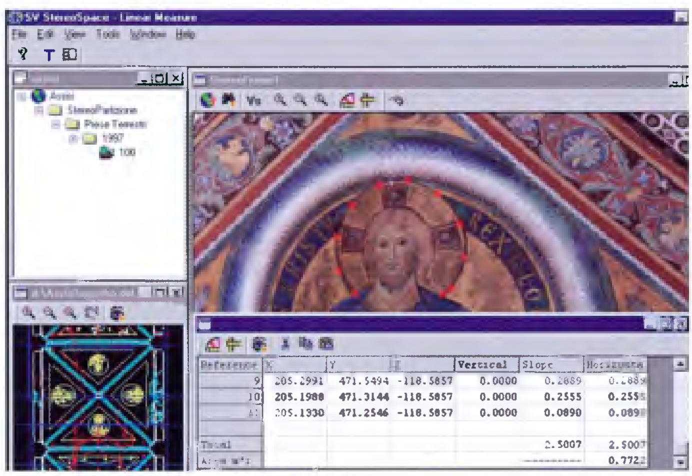

Figure 2. StereoSpace system: on the left is the tree view and the overview window, on the right the stereo frame and the measurement window. One of the system's principal features is the possibility of taking measurements in 3-D. You just click on points and wait for the results. You will have the coordinates of each point, distances between them, perimeter and area. This table is exportable in Excel. The subject is the vault of the upper basilica of Assisi.

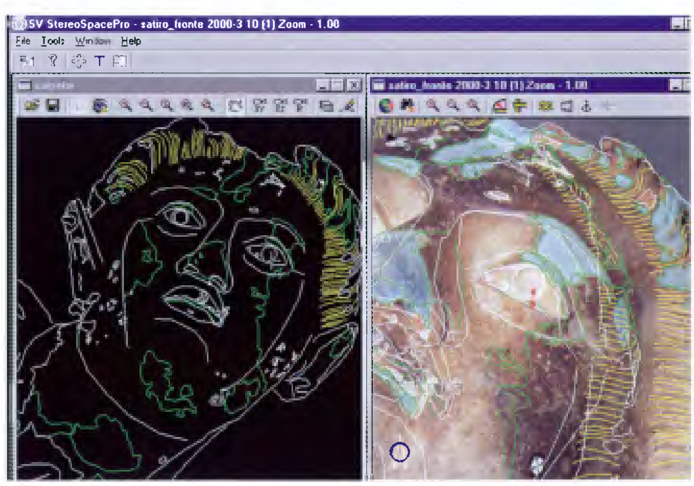

Figure 3. StereoSpace system: on the left is a CAD window with an imported *.dxf and on the right the corresponding stereo frame. You can see the drawing on the raster thanks to a special function of vector superimposition. The software allows tracing of a condition map or thematic map. The subject is the Satyr by Mazzara del Vallo – Data from FOART.

Figure 4. StereoSpace system: On the right are two opened stereo frames. Software permits opening several windows to make interesting comparisons between different zones. This feature is extremely efficient if you have two models from different time periods or showing different techniques.

Figure 5. SV Triangulation system: This figure shows the collimation phase of the absolute orientation work phase. You have to choose homologue points on the various photos and associate them by simply clicking on them. This is one of the preliminary moments of the model creation.

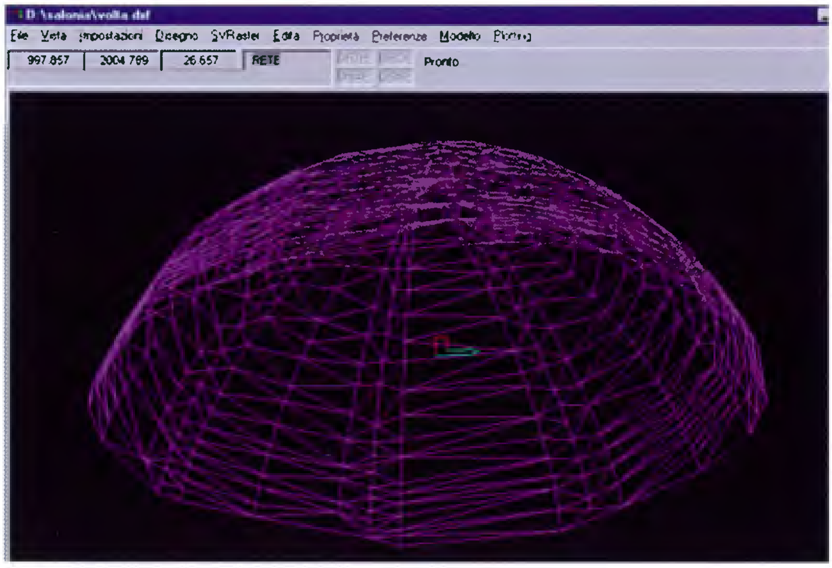

Figure 6. StereoView: Triangular Irregular Network (TIN) elaboration. The software automatically creates the distribution of points. The subject is the dome of the church of Purgatory in Terracina, Italy.

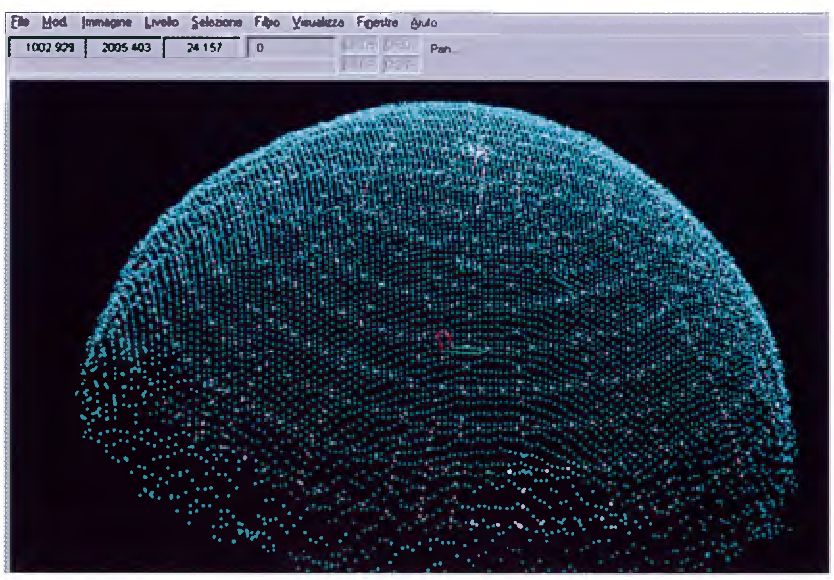

Figure 7. StereoView: Digital Elevation Model (DEM) elaboration. The software automatically creates distribution of points. The subject is the dome of the church of Purgatory in Terracina, Italy.

23
SELECTIVE SURVEY OF EXISTING GUIDELINES FOR CONSERVATION DOCUMENTATION

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INTRODUCTION

The search for material referring specifically to documentation issues in the world of heritage conservation is a difficult one. If, moreover, this research were restricted to the documentation of mural paintings, it would be truly impossible due to the lack of references. It is therefore necessary to refer to codes and norms relating to the architectural context and to identify methodological affinities. Indeed, principles and methods of documentation are never confined to a particular type of heritage.

The survey focused primarily on charters, codes of ethics and guidelines. Charters in the field of heritage conservation have a mainly proclamatory, didactic and sometimes administrative purpose. These documents are usually the result of expert meetings and declare a general, methodological intention and the need to develop prescriptive instruments for application at a local (national) level.

The numerous codes of ethics and guidelines have a different goal. They describe the steps and contents of the documentation process with the final aim of being the basis for the production of standardized procedures and operational protocols.

Interest in historic monuments as evidence and documents is the major thrust of a conservation theory that was outlined by Camillo Boito at the end of the 19th century. As early as 1883, Boito promoted the need for graphic and photographic documentation. He laid the foundation on which, in the 1930s, increasingly detailed administrative definitions of the form and contents of cultural heritage documentation were developed.
The Charters of Athens and Venice express the need for publication and accessibility of documentation. Article 16 of the Venice Charter has become an important and often-quoted point of reference in this field.

In the early 1960s, an initiative of the US section of IIC, promoted by professional associations of conservators, led to the definition of practice-oriented codes of ethics. The one published in Studies in Conservation in 1964 by the IIC-American Group (today AIC) establishes details such as the contents of reports and the type of photographs to be produced. The definition of a minimum documentation was already proposed in the 1956 ICOM resolution referring to the treatment of paintings.

Why, what and how to document? A first framework document with the title Principles for the Recording of Monuments, Groups of Buildings and Sites was proposed by CIPA, following the initiative of a working group at the 11th General Assembly of ICOMOS in 1996, and was approved at the same meeting. This document is given here below almost in full. Although dedicated to architecture, it covers virtually all the issues relating to the planning, management, processing and presentation of documentation.
The Appleton Charter (Canada) had already provided a contribution to the question of when documentation enters the process of conservation.

ICOM's own code of ethics, although not referring directly to documentation, stresses the need for a methodological and scientific approach to all examination activities.

In 1986, Australia adopted a Guidance for Conservation Practice partly inspired by the AIC production; in the meantime, the AIC continued upgrading the initial document following a thematic approach, with documentation being one of these themes.
It was, however, only with the E.C.C.O. document that the specific purpose and contents of documentation were addressed. Documentation contains part of the history of the object and is tied to it, becoming the key for its comprehension. This document inspired numerous translations and further ramifications. Of particular importance amongst these is the Code of Ethics of the Dutch Association of Professionals, which also addresses the economic aspect, stating that documentation must be considered an integral part of the conservator's work.

In the mid 1990s, a long process of collective discussion led to an updated version of the AIC guidelines and in 1999, the Canadian Association for Conservation produced their Code & Guidance for Practice.

A key monograph on mural painting conservation has also been included in this survey – the book by Mora, Mora and Philippot on *The Conservation of Wall Paintings*. Chapter 2 – on Examination and Documentation – is the only quoted literature reference. Due to its multilingual publication and broad circulation, it is probably the most widely observed 'guideline' for mural painting conservators worldwide.

The author is aware that this survey is far from complete, especially with regard to national documents from countries other than Italy. All the documents mentioned in this introduction are given below in chronological order. Only the most significant parts were transcribed, and omissions are indicated by the sign (...). The source is indicated on the bottom line under each quotation. The URL address is given for several documents that were collected from the Internet.

Chronological Table of Documents Examined

	Charter	Codes of ethics	Professional Guidelines
1883		IV Congresso degli Ingegneri ed Architetti Italiani	
1931	Athens Charter		
1932			Norme per il restauro dei monumenti
1938			Istruzioni per il restauro dei monumenti
1956		ICOM Motion n°13	
1963		IIC Murray Pease Report	
1964	Venice Charter		
1981	Burra Charter		
1983	Appleton Charter		
1984		ICOM-CC Code of ethics	
1986		AICCM Guidance for Conservation Practice	
1993		E.C.C.O. Professional Guidelines	
1994		ARI Codice deontologico del conservatore restauratore	
		AIC Guidelines for practice	
1995		Dutch association of professional restorers. Code of Ethics	
1996			ICOMOS Principles for the recording of monuments, groups of buildings and sites
1999		CAC/CAPC Second Draft of the Code of ethics & Guidance for practice	
2000		ICOM Revision of Professional Codes of ethics	

1883 - Camillo Boito, Relazione Finale al IV Congresso Ingegneri Architetti Italiani.
(...) Article 6:
Dovranno eseguirsi, innanzi di por mano ad opere anche piccole di riparazione o di restauro, le fotografie del monumento, poi (...) le fotografie dei principali stati del lavoro, e finalmente le fotografie del lavoro compiuto.
Questa serie di fotografie sarà trasmessa al Ministero della Pubblica Istruzione insieme coi disegni delle piante degli alzati e dei dettagli (...) ove figurino (...) tutte le opere conservate, consolidate, rifatte, rinnovate, modificate, rimosse o distrutte. (...)
Reference: Di Stefano, R.; Fiengo, G., "Norme ed orientamenti per la tutela dei Beni culturali in Italia", *in Restauro*, 40 (1978).

1931 - The Athens Charter for the Restoration of Historic Monuments. (The Athens Charter)
(...) The Conference expresses the wish that:
Each country, or the institutions created or recognised competent for this purpose, publish an inventory of ancient monuments, with photographs and explanatory notes;
Each country constitute official records which shall contain all documents relating to its historic monuments;
Each country deposit copies of its publications on artistic and historic monuments with the International Museums Office;

The Office devote a portion of its publications to articles on the general processes and methods employed in the preservation of historic monuments;
The Office study the best means of utilising the information so centralised. (...)
Reference: URL = http://www.icomos.org/docs/athens_charter.html

1932 - Consiglio Superiore per le Antichità e Belle Arti. Ministero Educazione Nazionale, Italy. Norme per il restauro dei monumenti.
(...) Come nello scavo, così nel restauro dei monumenti sia condizione essenziale e tassativa, che una documentazione precisa accompagni i lavori mediante relazioni analitiche raccolte in un giornale del restauro e illustrate da disegni e da fotografie, sicchè tutti gli elementi determinati nella struttura e nella forma del monumento, tutte le fasi delle opere di ricomposizione, di liberazione, di completamento, risultino acquisite in modo permanente e sicuro. (...)
Reference: Di Stefano, R.; Fiengo, G., "Norme ed orientamenti per la tutela dei Beni culturali in Italia", *in Restauro*, 40 (1978)

1938 - Ministero Educazione Nazionale, Italy. Istruzioni per il restauro dei monumenti.
(...) Di tutti i restauri dovrà essere curata un'esauriente documentazione grafica e fotografica, accompagnata da una relazione sui procedimenti tecnici seguiti, sugli elementi storici eventualmente venuti in luce, sui risultati finali dei lavoro.
Tali documentazioni, siano esse relative a monumenti o a opere d'arte, verranno conservate nell'Archivio Centrale del Restauro, presso l'Istituto Centrale del Restauro in Roma. (...)
Reference: Di Stefano, R.; Fiengo, G., "Norme ed orientamenti per la tutela dei Beni culturali in Italia", *in Restauro*, 40 (1978)

1956 – ICOM. 4th General Conference and 5th General Assembly of ICOM, Geneva, Switzerland, 9 July 1956. Motion No. 13: Documentation on the Treatment Given to Paintings.
1. Whereas even in large museums considerable work is done on paintings, even on great masterpieces, without there being sufficient documentation established of the state of the painting before, during and after treatment,
2. Whereas this procedure makes impossible, as emphasized by the ICOM Commission for the Care of Paintings, any serious appreciation by specialists of today and future historians of the work done on paintings,
3. Whereas it is preferable, except in emergencies, to postpone restoration, if means to ensure insufficient documentation are lacking,
ICOM Recommends
1. That a minimum documentation consisting of photographs in black-and-white and, if possible, in colour be made for every painting before, during and after treatment,
2. That within the museum's means in technical equipment and qualified personnel, and according to the requirements of each case, there be added a photographic record of examinations made by raking light, by filtered ultra-violet rays (fluorescence), by infra-red rays, by X-rays and possibly by microscope.
Reference: URL = http://www.icom.org/resolutions/eres56.html

1963 - I.I.C. American Group Standards of Practice and Professional Relations for Conservators. Report of the Murray Pease Committee.
(...) IV. Procedure for engaging in and reporting of examination and treatment of works of art by professional employees of institutions
A. *Report of examination.* Such reports shall include, in writing, the following information.

1. Date of examination and name of examiner.
2. Identification of object with that in report. This may be done by photographs, word descriptions, measurements and accession numbers.
3. Descriptions of materials, structure and method of fabrication. Physical, chemical and biological identification of materials composing the object. Statement of method of determination employed or reference to published standard method.
4. Record of alteration and deterioration. Locations and extent of physical defects, chemical alteration and its products, previous repairs and compensation. Statement of method of determination sufficiently detailed to permit duplication by another examiner.
4. Deductions or interpretations of observations and analyses. Comments relative to the degree of alteration.
5. Where evidence indicates forgery, every available test which can supply information on materials and structure shall be employed. After thoroughly checking his results the examiner shall recommend consultation with one or two disinterested individuals qualified by scientific or art historical training to review the evidence. (...)
C. *Report of treatment.* Such report shall include:
1. A statement of the procedures followed in the current treatment with exact descriptions of materials and methods, including:
(a) The method by which accretion or deterioration products were removed.
(b) Method and materials used in correcting distortion in form and shape and in reinforcing, consolidating, stabilizing and protecting structure and surface.
(c) Kind, extent and location of compensation employed.
2. Photographs as follows:
(a) Condition before treatment with date.
(b) Photograph in 'actual state' without compensation.
(c) Photograph after treatment with date.
(d) Photographs as required to supply data about structure, method of fabrication and state of object as revealed during process of treatment. Photographs or diagrams which clarify method of reconstruction or compensation. (...)
Reference:: *Studies in Conservation*, Vol. 9, N°3, August 1964, pp. 116-21

1964 International Charter for the conservation and Restoration of Monuments and Sites. (The Venice Charter)
(...) **Article 16.**
In all works of preservation, restoration or excavation, there should always be precise documentation in the form of analytical and critical reports, illustrated with drawings and photographs.
Every stage of the work of clearing, consolidation, rearrangement and integration, as well as technical and formal features identified during the course of the work, should be included.
This record should be placed in the archives of a public institution and made available to research workers. It is recommended that the report should be published (...)
Reference: URL = http://www.international.icomos.org/e_venice.htm

1981 – ICOMOS-Australia. The Australia ICOMOS Charter for the **Conservation of Places of Cultural Significance. (The Burra Charter)**
(...) **Article 23.**
Work on a place must be preceded by professionally prepared studies of the physical, documentary and other evidence, and the existing fabric recorded before any disturbance of the place.
(...) **Article 25.**
A written statement of conservation policy must be professionally prepared setting out the cultural significance, physical condition and proposed conservation process together with justification

and supporting evidence including photographs, drawings and all appropriate samples. (...)
Reference: URL = http://www.icomos.org/docs/burra_charter.html

1983 - ICOMOS-Canada. Appleton Charter for the Protection and Enhancement of the Built Environment. (Appleton Charter)
(...) **D Documentation:**
The better a resource is understood and interpreted, the better it will be protected and enhanced. In order to properly understand and interpret a site, there must be a comprehensive investigation of all those qualities which invest a structure with significance.
This activity must precede activity at the site. Work on site must itself be documented and recorded. (...)
Reference: URL = http://www.icomos.org/canada/appleton_charter.html

1984 ICOM-CC. Triennial meeting in Copenhagen in September 1984. The Code of Ethics.
(...) 3.4 The conservator-restorer must be aware of the documentary nature of an object. Each object contains – singly or combined – historic, stylistic, iconographic, technological, intellectual, aesthetic and/or spiritual messages and data. Encountering these during research and work on the object, the conservator-restorer should be sensitive to them, be able to recognize their nature, and be guided by them in the performance of his task.
3.5 Therefore, all interventions must be preceded by a methodical and scientific examination aimed at understanding the object in all its aspects, and the consequences of each manipulation must be fully considered. (...).
3.6 An intervention on an historic or artistic object must follow the sequence common to all scientific methodology: investigation of source, analysis, interpretation and synthesis. Only then can the completed treatment preserve the physical integrity of the object, and make its significance accessible. Most importantly, this approach enhances our ability to decipher the object's scientific message and thereby contribute new knowledge. (...)
Reference: URL = http://www.icom.org/ethics.html

1984 - L.& P. Mora, P. Philippot,The Conservation of Wall Paintings, London: Butterworth, pp. 25-34.
Extracts from chapter 2: Examination and Documentation (reading the entire chapter is recommended)
Aim and nature of documentation
Where the restoration of mural paintings is concerned, the purpose of documentation is to provide a detailed report of the results of the examination, the methods used and the conservation treatment. This must be prepared as clearly and completely as possible for the benefit of interested specialists. The recording of information is therefore a process which is inseparable from the examination and treatment, which it must follow step by step. Everything judged to be essential or even significant with regard to historical, archaeological and technological features of the work must be noted, as must data relative to the diagnosis of the causes of deterioration and the methods used in treatment. (...)
Who should be responsible for the documentation?
The interdisciplinary nature of restoration normally entails collaboration in the preparation of the documentation. Laboratory personnel naturally undertake responsibility for recording their investigations and treatments; the engineer or architect contributes relevant details regarding the stability of the structure which carries the paintings. It should logically be the same for the processes of examination and treatment carried out by the restorer, since he is, in this field, obviously in the best position to identify what must be recorded. (...) It is evident that whatever his technical pro-

ficiency, the photographer can only make accurate records if he completely understands their purpose as defined by the restorer. (...) In large scale operations, such as the restoration of an entire chapel entailing the collaboration of different specialists, the documentation can generally be coordinated satisfactorily only if responsibility for it is assumed by the appointment of a specialized person who is completely informed about the problems involved in the work.

Documentation of the work on the site

The location of a mural painting and its relation to the architecture usually require special graphic documentation (plans, sections, elevations). (...) drawings constitute a form of documentation essential for the restorer, and the only one which provides a clear and systematic record of the state of preservation of a complex ensemble and of the interventions carried out. For the documentation the use of a uniform scale, generally of around 1:20, is recommended, as is the system of developed diagrams which help in understanding the relation of the paintings to the architecture. The use of a simple, clear system of notation to record the data is also recommended. It is usually advisable to devise a system of symbols which can be applied with a minimum of equipment (since the restorer must often work *in situ* with limited means. These should preferably be in black and white only to facilitate reproduction of the documents (colours can be added to the final records). Finally, it is evident that the standardization of codes would be extremely valuable for easy comparison of different sets of documents.(...) To ensure that the results of the different technical examinations are in a form that is simple and easily interpreted, it is recommended that where possible a standard system of notation be adopted. These could be used on photographs to indicate the condition (...) If drawn on transparent paper such records could be superimposed, thus making it easier to establish their relationship to each other. (...) Apart from the general documentation, detailed records should be made of particular problems encountered and methods adopted for their solution. The purpose of these records is to show the nature of the changes and the restoration procedures; they should generally concentrate on areas of the painting chosen for their representative value. Complete documentation at this level is often unjustifiably expensive. (...)

Standardized and particularized documentation

Every form of documentation must satisfy two requirements which are sometimes contradictory: to record as accurately as possible the peculiarities of each specific case, and to facilitate comparisons by using a somewhat standardized method. The relative importance of each of these will vary according to the object in question, certain information being mostly of statistical interest, while other information may be essentially concerned with one individual case. With regard to this, one cannot be over-cautious concerning the increasing risk of allowing an overemphasis on standardized classification to impede the basic function of documentation. This is to record the particular nature of the phenomena by using whatever methods the specific case may require (...)

The accessibility of records

(...) Although the complete dossier of examination and conservation treatments must be held in special archives accessible to future restorers and other specialists, the publication *in extenso* of a restoration report is rarely desirable and such a report is nearly always difficult to read. It is essential, on the other hand, to publish all information of general significance (methods and results) which has not yet been disseminated and everything which is of particular importance for the work in question. (...)

1986 Australian Institute for the Conservation of Cultural Material**.** Guidance for Conservation **Practice.**

3. Documentation The conservator has an obligation to document his/her work by recording all essential details of the conservation of an object. Examination records and treatment records are an intrinsic part of the object; they should be kept in as permanent manner as is practical and be available for appropriate access. (...)

7. Examination Records The conservator shall make a thorough examination of the object and prepare an appropriate record before performing any conservation treatment. The conservator should

study relevant historical and technical records and where necessary shall initiate analyses of materials. From these records the conservator shall prepare an examination report which shall include details of composition, condition and case history. (...)
12. Treatment Record The conservator shall ensure that a record of techniques and materials used in conservation treatments is made and maintained as part of the documentation of an object. This record shall include justification and observations as well as any details of composition and condition which have been revealed during treatment. (...)
Reference: http://www.charvolant.org/~aiccm/coe.html

1993 - E.C.C.O. Professional Guidelines.
(...) Article 10.
Documentation of a cultural property should include records of the diagnostic examination, conservation and restoration interventions and other relevant information. This documentation becomes part of the cultural property and must be available for appropriate access. (...)
Reference: URL = http://palimpsest.stanford.edu/byorg/ecco/library/guidel.html#ethics

1994 - Associazione Restauratori d'Italia. Codice Deontologico del Conservatore-Restauratore.
(...) Article 9
Il conservatore-restauratore ha l'obbligo di documentare il proprio operato sul bene con particolare riferimento agli elementi che ne caratterizzano la conservazione (...)
Article 20
Al termine di ogni intervento il conservatore-restauratore redigerà una relazione descrittiva sulla natura dei trattamenti eseguiti, con specifico riferimento alle sostanze usate. Tale relazione, insieme al resoconto dell'esame preliminare, le testimonianze fotografiche e i rapporti scientifici delle analisi e gli eventuali campioni prelevati vanno a costituire la documentazione del bene culturale divenendone corredo storico ed analitico integrante (...)
Reference: Associazione Restauratori d'Italia (ARI), Il Conservatore-Restauratore, Definizione della Professione, Codice deontologico del Conservatore-Restauratore. 1994.

1994 - The American Institute for Conservation of Historic and Artistic Works. AIC Code of Ethics and Guidelines for Practice.
(...) **24. Documentation:** The conservation professional has an obligation to produce and maintain accurate, complete, and permanent records of examination, sampling, scientific investigation, and treatment. When appropriate, the records should be both written and pictorial. The kind and extent of documentation may vary according to the circumstances, the nature of the object, or whether an individual object or a collection is to be documented. The purposes of such documentation are:

- to establish the condition of cultural property;
- to aid in the care of cultural property by providing information helpful to future treatment and by adding to the profession's body of knowledge;
- to aid the owner, custodian, or authorized agent and society as a whole in the appreciation and use of cultural property by increasing understanding of an object's aesthetic, conceptual, and physical characteristics; and
- to aid the conservation professional by providing a reference that can assist in the continued development of knowledge and by supplying records that can help avoid misunderstanding and unnecessary litigation.

25. Documentation of Examination: Before any intervention, the conservation professional should make a thorough examination of the cultural property and create appropriate records. These records and the reports derived from them must identify the cultural property and include the date

of examination and the name of the examiner. They also should include, as appropriate, a description of structure, materials, condition, and pertinent history.
26. Treatment Plan: Following examination and before treatment, the conservation professional should prepare a plan describing the course of treatment. This plan should also include the justification for and the objectives of treatment, alternative approaches, if feasible, and the potential risks. When appropriate, this plan should be submitted as a proposal to the owner, custodian, or authorized agent.
27. Documentation of Treatment: During treatment, the conservation professional should maintain dated documentation that includes a record or description of techniques or procedures involved, materials used and their composition, the nature and extent of all alterations, and any additional information revealed or otherwise ascertained. A report prepared from these records should summarize this information and provide, as necessary, recommendations for subsequent care.
28. Preservation of Documentation: Documentation is an invaluable part of the history of cultural property and should be produced and maintained in as permanent a manner as practicable. Copies of reports of examination and treatment must be given to the owner, custodian, or authorized agent, who should be advised of the importance of maintaining these materials with the cultural property. Documentation is also an important part of the profession's body of knowledge. The conservation professional should strive to preserve these records and give other professionals appropriate access to them, when access does not contravene agreements regarding confidentiality. (...)
Reference: URL = http://aic.stanford.edu/pubs/ethics.html#seven

1995 - Dutch Association of Professional Restorers Code of Ethics.
(...) **2.7 Reporting**
The restorer must document his activities and the materials used in order to be able to consult the documentation in the future. At the request of the person commissioning the restoration the restorer shall make a detailed report recording methods and materials; the making of this report will be charged on the normal hourly tariff. The treatment report should contain the following matters:
1. A description of the manner of treatment with precise details of the materials and methods used, including:
a) the manner in which materials and parts were removed:
b) the manner in which and the materials (specifying manufacturer and supplier) with which activities on the form and composition of the object were carried out, such as reinforcements, stabilisers and protection of the surface and structure.
2. Photographic documentation, with accompanying text, of:
a) the condition of the object before treatment;
b) the condition of the object during treatment, including, where appropriate, details;
c) condition after treatment and visual aids which are necessary to provide insight into the structure and construction of the object which, in the course of treatment, were revealed to be different than had previously been thought, or which confirmed existing hypotheses.
Reference: URL = http://palimpsest.stanford.edu/byorg/veres/vereseth.html

1996 ICOMOS. 11th General Assembly in Sofia, Bulgaria, 5-9 October 1996. Principles for the **Recording of Monuments, Groups of Buildings and Sites.**
(...) **The Reasons for Recording**
1. The recording of the cultural heritage is essential:
a) to acquire knowledge in order to advance the understanding of cultural heritage, its values and its evolution;
b) to promote the interest and involvement of the people in the preservation of the heritage through the dissemination of recorded information;
c) to permit informed management and control of construction works and of all change to the cultural heritage;

d) 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.

2. Recording should be undertaken to an appropriate level of detail in order to:

a) provide information for the process of identification, understanding, interpretation and presentation of the heritage, and to promote the involvement of the public;

b) 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;

c) provide information for administrators and planners at national, regional or local levels to make sensitive planning and development control policies and decisions;

d) provide information upon which appropriate and sustainable use may be identified, and the effective research, management, maintenance programmes and construction works may be planned.

3. Recording of the cultural heritage should be seen as a priority, and should be undertaken especially:

a) when compiling a national, regional, or local inventory;

b) as a fully integrated part of research and conservation activity;

c) before, during and after any works of repair, alteration, or other intervention, and when evidence of its history is revealed during such works;

d) when total or partial demolition, destruction, abandonment or relocation is contemplated, or where the heritage is at risk of damage from human or natural external forces;

e) during or following accidental or unforeseen disturbance which damages the cultural heritage;

f) when change of use or responsibility for management or control occurs.

Responsibility for Recording

1. The commitment at the national level to conserve the heritage requires an equal commitment towards the recording process.

2. The complexity of the recording and interpretation processes requires the deployment of individuals with adequate skill, knowledge and awareness for the associated tasks. It may be necessary to initiate training programmes to achieve this.

3. Typically the recording process may involve skilled individuals working in collaboration, such as specialist heritage recorders, surveyors, conservators, architects, engineers, researchers, architectural historians, archaeologists above and below ground, and other specialist advisors.

4. All managers of cultural heritage are responsible for ensuring the adequate recording, quality and updating of the records.

Planning for Recording

1. Before new records are prepared, existing sources of information should be found and examined for their adequacy.

a) The type of records containing such information should be searched for in surveys, drawings, photographs, published and unpublished accounts and descriptions, and related documents pertaining to the origins and history of the building, group of buildings or site. It is important to search out recent as well as old records;

b) Existing records should be searched for in locations such as national and local public archives, in professional, institutional or private archives, inventories and collections, in libraries or museums;

c) Records should be searched for through consultation with individuals and organisations who have owned, occupied, recorded, constructed, conserved, or carried out research into or who have knowledge of the building, group of buildings or site.

2. Arising out of the analysis above, selection of the appropriate scope, level and methods of recording requires that:

a) The methods of recording and type of documentation produced should be appropriate to the nature of the heritage, the purposes of the record, the cultural context, and the funding or other resources available. Limitations of such resources may require a phased approach to recording. Such methods might include written descriptions and analyses, photographs (aerial or terrestrial), rectified

photography, photogrammetry, geophysical survey, maps, measured plans, drawings and sketches, replicas or other traditional and modern technologies;
b) Recording methodologies should, wherever possible, use non-intrusive techniques, and should not cause damage to the object being recorded;
c) The rationale for the intended scope and the recording method should be clearly stated;
d) The materials used for compiling the finished record must be archivally stable.

Content of Records
1. Any record should be identified by:
a) the name of the building, group of buildings or
b) a unique reference number;
c) the date of compilation of the record;
d) the name of the recording organisation;
e) cross-references to related building records and reports, photographic, graphic, textual or bibliographic documentation, archaeological and environmental records.
2. The location and extent of the monument, group of buildings or site must be given accurately - this may be achieved by description, maps, plans or aerial photographs. In rural areas a map reference or triangulation to known points may be the only methods available. In urban areas an address or street reference may be sufficient.
3. New records should note the sources of all information not obtained directly from the monument, group of buildings or site itself.
4. Records should include some or all of the following information:
a) the type, form and dimensions of the building, monument or site;
b) the interior and exterior characteristics, as appropriate, of the monument, group of buildings or site;
c) the nature, quality, cultural, artistic and scientific significance of the heritage and its components and the cultural, artistic and scientific significance of: the materials, constituent parts and construction, decoration, ornament or inscriptions, services, fittings and machinery, ancillary structures, the gardens, landscape and the cultural, topographical and natural features of the site;
d) the traditional and modern technology and skills used in construction and maintenance;
e) evidence to establish the date of origin, authorship, ownership, the original design, extent, use and decoration;
f) evidence to establish the subsequent history of its uses, associated events, structural or decorative alterations, and the impact of human or natural external forces;
g) the history of management, maintenance and repairs;
h) representative elements or samples of construction or site materials;
i) an assessment of the current condition of the heritage;
j) an assessment of the visual and functional relationship between the heritage and its setting;
k) an assessment of the conflicts and risks from human or natural causes, and from environmental pollution or adjacent land uses.
5. In considering the different reasons for recording (see Section 1.2 above) different levels of detail will be required. All the above information, even if briefly stated, provides important data for local planning and building control and management. Information in greater detail is generally required for the site or building owner's, manager's or user's purposes for conservation, maintenance and use.

Management, Dissemination and Sharing of Records
1. The original records should be preserved in a safe archive, and the archive's environment must ensure permanence of the information and freedom from decay to recognised international standards.
2. A complete back-up copy of such records should be stored in a separate safe location.
3. Copies of such records should be accessible to the statutory authorities, to concerned professionals and to the public, where appropriate, for the purposes of research, development controls and other administrative and legal processes.

4. Up-dated records should be readily available, if possible on the site, for the purposes of research on the heritage, management, maintenance and disaster relief.
5. The format of the records should be standardised, and records should be indexed wherever possible to facilitate the exchange and retrieval of information at a local, national or international level.
6. The effective assembly, management and distribution of recorded information requires, wherever possible, the understanding and the appropriate use of up-to-date information technology.
7. The location of the records should be made public.
8. A report of the main results of any recording should be disseminated and published, when appropriate. (...)
Reference: ICOMOS-CIPA Ad Hoc Working Group – 1996. ICOMOS Principles for the Recording of Monuments, Groups of Buildings and Sites. Co-ordinated by R. Letellier for ICOMOS-CIPA. Ratified by the XIth ICOMOS General Assembly, Sofia, 1996.

1999. Canadian Association for Conservation/ Association canadienne pour la conservation et la **restauration. Code & Guidance for Practice (Second Draft)**
(...) 4. Documentation:
The conservation professional shall document his/her work by recording all essential details of the conservation of a cultural property. The extent and type of documentation will vary with the nature of the cultural property and conservation work required. Documentation is intrinsic to the history of the cultural property and shall be produced and maintained in as permanent a manner as is practical and be available for appropriate access, when this access does not contravene agreements regarding confidentiality. (...)
9 Examination Report:
From examination records, the conservation professional shall prepare an examination report which shall identify the cultural property and include relevant information on its structure, materials, history and condition. The conservation professional shall provide a copy of the examination report to the owner. (...)
14. Documentation of Treatment:
Treatment records shall include the date of the treatment, a description of the interventions and of the techniques and materials (with their composition where known) used, observations, as well as any details of the cultural property's structure, materials, condition or relevant history which have been revealed during treatment. From these records a summary shall be prepared in the form of a treatment report. The conservation professional shall provide the owner with this report and shall stress the importance of maintaining the report as an intrinsic part of the history of the cultural property. (...)
Reference: URL = http://www.cac-accr.ca/ecoderev.html

2000 ICOM. Revision of the ICOM Professional Code of Ethics.
6.4 Documentation of Collections
The recording and documenting of collections in accordance with appropriate standards is an important professional obligation and responsibility. It is particularly important that collection documentation should include a complete description of all items, their provenance and source and the conditions of acceptance by the museum. Collection data should be maintained actively and augmented in the on-going life of the museum. Such data should be kept in a secure environment and be supported with retrieval systems providing access to the data by the staff and other legitimate users.
Reference: URL = http://www.icom.org/rev-ethics.html

24
RESULTS OF WORKING GROUP ACTIVITIES

BACKGROUND

About half of the available time on the seminar was dedicated to working group activities. During the planning meeting in February 2000 the following objective was set for this important project component:

- Define, through interactive working sessions, a framework for the correct documentation of mural paintings, which specifies the aims and indicates minimum requirements as well as desirable options; this framework will be the basis for the eventual development of guidelines.

To facilitate the process, it was decided to establish three complementary problem areas, each to be addressed by one working group. Moreover, a list of relevant issues relating to each theme area was drafted and further developed later on. All issues were formulated as concrete questions in order to focus discussion and to clarify the task of the working groups, which would basically consist in developing a commentary in response to each of them. Theoretically, the three working group out-puts combined would make up the framework document.

During the seminar, it became clear that the set objective was too ambitious and that it was not realistic to hope to achieve a consensus on such controversial topics in such a short time.

The wording of the objective, especially the last part of the first sentence, regarding 'minimum requirements' was thoroughly discussed during a first plenary session, with the resulting consensus regarding the impossibility of giving general indications on such a minimum as it would always depend on specific project needs (see Chapter 25). Moreover, several justified concerns were expressed with regard to the goal of producing a publishable Framework Document, which would eventually be used for the drafting of guidelines. GraDoc participants felt that such an important and highly desirable document would need considerably more time and the participation of a broader segment of the international conservation community.

It is in the interest of ICCROM and of all GraDoc partners and participants to stress that the Working Group Documents published hereunder are the unfinished products of a work in progress which expresses solely the opinion (in some cases controversial) of the experts who attended the meeting.

These documents are not guidelines, nor do they constitute a framework for their eventual development. They rather constitute a think tank for the necessary continuation of this discussion with the involvement and participation of interested institutions and individuals worldwide. It is the hope of all GraDoc participants that the initiated process will have an adequate and effective follow-up.

The documents are published in their 'authentic' form, which reflects the individual working method of each group. All documents are structured according to the list of issues that was drafted prior to the meeting and finalized by each working group.

Working Group 1

FUNCTIONS OF DOCUMENTATION IN MURAL PAINTING CONSERVATION AND SPECIFIC FUNCTIONS OF GRAPHIC DOCUMENTATION

Group moderator:
Sharon CATHER
Group members:
Nimal DE SILVA
Jacques NEGUER
Jürgen PURSCHE
Walter SCHUDEL
Kirsten TRAMPEDACH
Konrad ZEHNDER

APPROACH

Given the inevitable time constraints of the seminar, the working group discussions were greatly facilitated by the preparation by the coordinators of a discussion document posed as a series of questions and divided into three principal areas. Therefore, the GraDoc participants – all experienced in wall painting conservation generally and its documentation in particular – were divided into three corresponding working groups. Although both the interest and expertise of the various participants obviously crossed the boundaries of these three areas, this overlap was adequately compensated for both by plenary discussions during the workshop, and by the opportunity to comment individually afterward.

Each working group met separately for an afternoon of intensive discussion and then reported back to the full group with a draft document, allowing both feedback from other participants and a revision of the draft based on the plenary discussion. This revised draft was then discussed again in full session at the conclusion of the seminar, and further substantial revisions were made. Finally, an extended period after the seminar was allowed for individuals to comment on the draft, which was yet again revised.

A few brief comments on this process and the resulting document for Working Group 1 are in order. While recognizing that the issues considered could have been approached in various ways, the participants accepted the structure provided by the coordinators and worked to that. They also recognized that a thorough investigation of existing guidelines and literature would have been highly desirable, but acknowledged that the document would serve primarily as a basis for further discussion and revision and was in no sense definitive. Although there was broad agreement on many issues, there was rarely unanimity. Since the present document does not preserve these alternative views, it would be misleading to suggest that it represents anything more than a draft consensus framework requiring further input.

GENERAL ISSUES OF DOCUMENTATION

1.1. *What is conservation documentation?*[1]

Conservation documentation is the systematic collection, creation, structuring and ensuring of access to information from investigations, interventions, monitoring, and maintenance. Documentation formats include text, image, graphic and an increasing variety of data formats generated by examination, analytical and recording techniques.

1.2. *Why do we document?*[2]

Although the obligation to document is universally acknowledged, both the reasons for documenting and the functions of documentation vary considerably. The following division is primarily functional, and is intended to reflect current practice.

1.2.1 *Ethical obligation*

- To provide a permanent and accessible record for conservation professionals and the public of the state of conservation, of interventions, and of information which aids preservation and the assessment and interpretation of values;
- To increase knowledge of the object and its context that will enhance appreciation and minimize interventions.

1.2.2 *Public benefit*

- For presentation at site of painting;
- For posterity.

1.2.3 Conservation tool

Management

- To aid in identifying and evaluating significance/values to promote interest, understanding and involvement in the object;
- To aid risk assessment, including by contributing to inventories/listing;
- To aid in planning, sequencing and budgeting interventions by defining, localizing and quantifying phenomena;
- To provide an archival record for developing a long-term plan of future assessment, maintenance and monitoring; and
- To facilitate communication about the nature and care of the object to reduce further deterioration and the need for further interventions.

Investigation

- To record materials and techniques of execution of relevance to historical significance, condition, treatment, and/or maintenance;
- To record the nature and distribution of decay (including patterns of deterioration) to help interpret and address the causes of deterioration with particular reference to the structural and environmental context;
- To allow synthesis of information and investigations with a view to making interim interpretations and determining specialist investigations required;
- To record effects of past treatments, to assess the success and failure of past materials and methods of treatment;

Intervention

- To produce a current record of relevant aspects before intervention;
- To familiarize the conservator with the painting and its condition; and
- To provide a basis for recording and monitoring of interventions.

1.3. What types and levels of information should be documented?

In general, all information relevant to the conservation of the painting should be documented. The nature of documentation **assembled** or **generated** for a specific painting is a matter of professional judgement, and is related to:

- the significance and complexity of the painting, its current condition, and its physical history;
- the relevance of the documentation to the preservation of the painting;
- the physical/logistical constraints (such as size and accessibility);
- the resources available; and
- the value of the documentation for other purposes (eg historical information).

1.3.1 Minimum documentation

Although the type and quantity of documentation may vary substantially, there is considerable consensus that the following categories of information are required as a minimum:

- assembly of previous documentation, including production of a list of what it contains (briefly) and where it can be found;
- interpretation of previous documentation, including a brief physical history of the painting and its site and a chronology and interpretation of significance of previous interventions;
- a statement of significance/values, and a description of the present and likely future use of the building/site;
- a materials assessment of the painting (including technique) and its support;
- an assessment of condition and risk, incorporating interpretation of any technical investigations;
- a record of all interventions carried out, including justification statements and detailed specifications with regard to materials and application techniques for each operation;
- an evaluation/statement of the state of conservation after intervention and recommendations for future maintenance and monitoring.

1.4. What are the usual steps in the process of documentation?

Documentation requires a statement of objectives and considerable planning, but nonetheless should remain sufficiently flexible to accommodate new objectives and methods. It should also be an iterative and critical process, involving periodic review and restatement of objectives.

- explicit definition of aims and objectives of the documentation; this statement forms part of the permanent record;
- assembly and evaluation of existing information;
- determination of levels of recording and detail to meet the objectives;
- decision on how this information can best be documented and what methods of recording are feasible and appropriate;
- recording process (for investigations, interventions, maintenance and monitoring);
- manipulation and presentation of data;
- data synthesis, correlation and interpretation (as appropriate);
- information management, including preservation, access, and storage.

1.5 *Who produces documentation?*

Documentation may be assembled, generated, processed, manipulated and presented. The specialists involved in each of these processes will depend on the nature of the activity and the skills required, and may be determined by local legislation or policy. In the most straightforward cases, all of these activities may be undertaken by the conservator, whereas in complex cases it is likely that this will involve a **multidisciplinary team**, including a number of highly specialized professionals. In such a case, normally:

- **coordination** of documentation requires management skills;
- **generation** of new information requires a professional; for example, condition assessment of a painting *must* be done by a conservator;;
- **processing** of assembled and generated data may require specialist skills in information technology, and may be carried out by a documentation specialist (documentarist); it is highly desirable that this specialist have an understanding of the conservation issues;
- **assessment/interpretation** of documentation is a multidisciplinary activity, involving a range of professionals.

1.6 *Who uses the documentation?*

Use of the documentation will depend on the documentation objectives, the nature of the information, and the formats. Since the principal purpose of documentation is usually for the conservation of the painting, the typical users of the information are those involved in the conservation process, for example:

- conservators;
- conservation administrators, clients, etc.;
- art historians, architects, archaeologists, etc.;
- specialists in related fields; or
- funding bodies.

In addition, much documentation is of considerably wider interest and may be used, for example, by:

- scholars:
- educators;
- the public.

1.7 *Who manages the information, and how is it preserved, stored and accessed?*

Issues of management, preservation and accessibility of documentation have **ethical**, **administrative** and **technical** aspects.

1.7.1 Ethical

- There is a clear ethical responsibility for permanency and dissemination of conservation documentation. However, these aspects are complicated by the fact that wall paintings are often at sites where it is not feasible to maintain documentation records (an administrative issue), and by the multiplicity and complexity of documentation formats (a technical issue).

1.7.2. Administrative

- There may be national or regional regulations and procedures for the preservation, storage and access of documentation records.
- Documentation records (or a copy) should be accessible to relevant professionals and the public; this has both resourcing and copyright implications.

1.7.3. Technical

- Documentation records should be on stable media and appropriately stored. Permanency is critical, particularly for

electronic and magnetic media.[3] Therefore, there is some consensus that the production of black and white photographs remains highly desirable.
- A second copy should be stored at another location.

ISSUES RELATING TO GRAPHIC DOCUMENTATION

Graphic documentation may take a variety of forms (such as line drawings or symbols on a base map). It may be used to convey an aspect of the object, such as its content or condition, in which case it is an abstracted, interpreted visualization based on knowledge and experience. It may also be a record of investigations, interventions, and monitoring.

1.8 *What are the specific aims of graphic documentation in relation to other documentation formats?*

The core of documentation is the text. Images and graphic records are used to illustrate and visualize aspects that can be more effectively conveyed in those formats. Graphic documentation is particularly suitable to describe topographic and stratigraphic information . Graphic records and images are complementary and not separable from the text. Graphic documentation allows clarification, explanation, or emphasis of particular aspects (such as condition or treatments), and/or correlation between them. When graphic documentation provides 'layers' of information, it allows interrogation of information in several different ways.

Graphic documentation can be used to:
- visualize information clearly and concisely;
- illustrate patterns
- quantify features recorded;
- correlate information and demonstrate relationships between the information recorded.

1.9 *How can graphic documentation be used as a management tool?*

Since graphic documentation is useful for *localizing* and *quantifying* phenomena it can aid in the management of investigations, **preventative, passive,** and **remedial** interventions, and for **monitoring**. For investigations, it can define and localize phenomena which aids the determination of appropriate investigations and informs sampling strategies. For remedial interventions, it can be used for *planning, sequencing* and *costing* interventions. For example, for determining the specific interventions required, the areas to be treated, and the order in which treatment should proceed. Similarly, for preventative and passive interventions it can aid in diagnosing causes of deterioration and/or their activation mechanisms. For example, localization of mechanical damage may indicate preventative measures required near room entrances

1.10 *How can graphic documentation be used as a monitoring tool?*

A common misconception is that graphic documentation can automatically serve a dual function as a static record at a given time and as a monitoring tool. To be effective as a monitoring tool, the accuracy of the record and the scale used are significant. Moreover, monitoring presumes an understanding of and some potential to predict the nature, scale and rate of change to be monitored. Monitoring of a painting using graphic documentation can only be adequately achieved by pre-planning the monitoring process. For detailed monitoring of the state of conservation a useful method is to select an adequate number of representative areas and record the condition at an appropriate scale (such as 1:5 or 1:1); larger scales (1:10-1:50) are used for monitoring macro-conditions, such as moisture damage. Monitoring may also be done by means of photography at a scale appropriate to image the condition being monitored, taken from a specified location and under set conditions and repeated at intervals to assess change. Often this method is combined with graphic recording, using the same photographs as a base map.

1.11 *How can data from related investigations be integrated?*

To graphically integrate the data, a shared/common base map is required. Typical examples include measured (or preferably photogrammetric) elevations or rectified photographs. In its simplest form, data integration can take the form of mapping of information on the base map. In its most useful form it involves integration by means of GIS (see WG3). This allows precise three-dimensional integration of spatial data (such as historic images, sampling locations, infrared thermography, or multispectral imaging) and simultaneous interrogation of other forms of data (such as spectra or photomicrographs).

Working Group 2

ANALYSIS OF THE GRAPHIC DOCUMENTATION PROCESS

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APPROACH

To provide initial focus for the discussion sessions, Working Group 2 (WG2) was presented with a number of questions relating to the process of graphic documentation. However, the WG2 participants decided to structure their discussions according to the three elements of the graphic documentation process: Planning, Data Collection, and Data Organization. The various questions posed to the group were discussed in relation to this structure, and are included where relevant. The purpose of the working group was to explore and debate the process of graphic documentation of mural paintings. The resulting document is neither exhaustive nor compete, and moreover it is not intended to serve as a prescriptive model. Nonetheless, it is hoped that this initial draft document begins the process of defining the graphic documentation process, and that the issues raised will stimulate wider discussion and new initiatives in this area.

INTRODUCTION

Graphic documentation of mural paintings – the focus of GraDoc – constitutes only a part of conservation documentation. The draft terminology provided to the GraDoc participants defined graphic documentation as *the product of recording phenomena or other data, created by superimposing symbols, patterns or colours over a base map*. However, following discussion by the group, this definition was widened and simplified to encompass all types of annotation on a pictorial form.

The working group subdivided the **graphic documentation process** into three sequential steps:

- planning;
- data collection; and
- data organization.

These were further subdivided, as outlined and discussed below.

1. PLANNING

Defining **objectives**

A first and vital component of the process is to define specific objectives for the documentation, and to allocate sufficient resources to achieve these aims. While this planning stage is often neglected, it must be considered as fundamental to the success of a project, rather than as an adjunct to data collection. For example, by defining the type of information needed, one can establish the level of detail required, thus reducing the risk of collecting unnecessary or redundant data. At the outset of a project, it is important to consult existing archive documentation and to identify the intended functions and use of the new – and potentially complementary – documentation. It is recognized that objectives may continue to evolve throughout a project, and consequently the longer-term functions and uses of the documentation should be anticipated during the planning stage.

Selection of recording method

The selection of the most appropriate method or methods will depend on the project objectives and resources available, and other factors, such as access to the paintings. Recording methods vary widely, from annotation of line drawings or photographs, to *in situ* computerized data input. Perhaps the most widely used recording method is hand-annotated overlays on a photographic base map. This method can be entirely appropriate and is often also quite cost effective. Nowadays, these overlays are typically subjected to a further *ex situ* process whereby the hard-copy information is digitized, allowing digital manipulation, presentation and storage. Increasingly, computers are used on site for direct *in situ* input of data. It is generally accepted that computerized documentation allows greater flexibility in manipulating and presenting data than graphic documentation recorded on physical transparencies. Recent developments have afforded the possibility of integrating such digital information into spatially related image databases (such as geographical information systems – GIS).

Where possible, it is desirable to integrate new data with existing recorded information. This is not always easy, and sometimes not desired by conservators, given the – perceived or real – inadequacies of much previous documentation. Despite these difficulties, one should strive to extract maximum value from historical graphic documentation to help ensure that new information is complementary and promotes synergistic rather than fragmentary documentation. It is important to recognize that the transformation of visual observations to hardcopy or digital format will inevitably involve a certain amount of distortion. The potential for error increases in situations where different individuals undertake different components of the data transfer process; if transfer processes are undertaken *ex situ*; and when non-conservators undertake information transfer. *In situ* digital recording by conservators is beneficial, insofar as it avoids a second transfer stage and facilitates direct cross-reference with the painting.

The discipline of undertaking drawings *in situ*, should not be underestimated since the activity of drawing itself can promote the detailed visual study of a painting. While *in situ* computer documentation can be used in a similar way to promote visual inspection, there is nonetheless a potential for distancing the conservator from the painting by focusing attention on the – 2-D – screen image rather than the wall.

Establishing nomenclature

For every site and project it is essential that nomenclature, terminology and graphic symbols be clearly and consistently named, defined and agreed upon from the outset. This clarity will aid communication between the conservation team and facilitate future use of the documentation. These 'standards' should be used consistently throughout all the documentation generated as part of a specific project. Similarly, in sites with multiple wall paintings, a 'site standard' that defines nomenclature, terminology and graphic symbols can be useful to facilitate easy interpretation and comparison of data from the same site (see WG2 Question 1).

Establishing what information to record

The information to be recorded is determined by the examination of the painting and the objectives of the project. During the preliminary examination, a list of the features to be recorded in graphic form is typically formulated, forming the project legend. It is helpful if this list can be combined with a written and visual glossary to ensure homogeneity in the recording and interpretation of data. In addition, a visual glossary is a useful tool when presenting and discussing information with those not directly involved with the conservation programme. This glossary or visual glossary should be thought of as an evolving document that needs to be revised and re-evaluated as the project progresses and as the conservators gain familiarity with the site.

Practical preparation

The initial planning phase ends with preparation to go on site for data collection. Preparatory activities include: preparation of photos or drawings for base maps; acquisition of necessary recording tools and materials (pens, paper, overlays, clipboards, etc.); preparation of the visual glossary (legend); and, if the work is planned for digital processing, loading of relevant software and base maps onto the computers.

2. DATA COLLECTION

During this phase the conservation team thoroughly examines the site and paintings, recording the type, location, and extent of phenomena identified in the planning phase. The recording process requires that each individual feature can be observed, identified, named and defined. During this phase, non-invasive examination techniques can be utilized to aid in the observation and recognition of features. The processes of examination and recording are inevitably subjective, but every effort should be made to ensure a high level of consistency and accuracy in recording.

Development of the legend and visual glossary
It is important that after a certain period of careful examination of the painting, the conservation team reviews the list of features recorded. An element may have been found to have two manifestations that must be graphically differentiated; or an element listed may be deemed less relevant and hence not need recording. Or, when a phenomenon occurs systematically in particular areas of the surface, the conservator may decide that its distribution can be described in written form and it is not necessary to continue recording it in graphic form. It will be easier for an experienced conservator to refine the list and identify the relevant features to be recorded. However, as a general rule, it is useful during the graphic data collection phase to call a halt after the first few days of work and evaluate the list of features to be recorded in graphic form.

Verification of data
It is important to schedule time for review and control of the graphic records within the overall project plan. Cross-checking between the work of team members as well as having one experienced conservator overseeing the entire documentation process can help. Computers are also being used with increasing frequency on site, allowing easy verification of data in case of any uncertainties arising during the interpretation and transfer of data from the hardcopy record to the computer.

3. DATA ORGANIZATION

This component includes the operation of adapting the information collected in the field into a clear, legible and usable format. The following discussion specifically relates to the transfer of hard-copy graphic documentation to digital data format. When possible, having the graphic record in digital form is advantageous as it provides most flexibility in all components of the data organization step. The information recorded in the field can either be manually copied onto a computer, or scanned and overlaid over the digital base map. Transferring data from hardcopy to digital form involves manually tracing with a digitizing tool the records mapped in the field. This time-consuming and tedious operation is very prone to error. An easier method, less subjective to human error, is to scan the records and position information and store it as an appropriate layer in digital form. The record should include registration marks for correct repositioning of the information at the appropriate scale, and should have been planned for. Direct recording, which involves the inputting of information directly from the wall painting to a computer, is beneficial as it avoids the transfer stage completely and, at the same time, is ideally more efficient. However, costs, the logistical constraints of most wall painting sites, the computer skills required, as well as the current lack of mobility of most computer systems, limits this application.

Data manipulation and interpretation
This stage allows us extract maximum information form the data recorded. The basic structure of information often involves the use of layers, which if speaking about condition, means each decay feature is recorded on its own individual layer. This enables us to compare various layers, such as the relationship between cracks and areas of delamination. The use of layers is achieved by superimposing transparent layers over a base map or by creating layers in computer graphics programs. Computer graphics programs allow the user to choose a colour or pattern to represent any particular layer and can easily allow the user to select and view those layers they want visible. A 'layer manager' allows one to control the layering order of individual phenomenon, and which layers you wish to have visible. (See WG3 for more discussion of computer-aided systems).

Data presentation
Presentation – the act of visually communicating recorded data – demands that data be put into a specific format to convey information to a desired audience. The format and level of presentation should take into account the intended audience and appropriate technology. Typically, only part of

the data is ever presented, and effective communication requires selective editing of the collected information.

Documentation is an ongoing process and one should ideally be able to build upon and supplement existing documentation. Having the data in digital form facilitates this process. Moreover, computer technology has provided new and innovative ways of presenting data effectively. However, computer-generated documentation can also convey a false sense of completeness and accuracy. Be it digital or hardcopy, it is important to ensure that the integrity of the recorded information is not compromised by the means of presentation.

Selection of graphic symbols and colour

There seems to be some disagreement regarding the selection and use of graphic symbols and colour in graphic recording. Some feel that a standard should exist and should be followed for all graphic documentation. Others feel that the use of graphic symbols or colour should depend on the purpose of the presentation and the expected audience, and hence selected primarily to make the presented information as clearly readable as possible. With computerized documentation this choice becomes less important as it is easy to change options.

Preservation, storage and accessibility

One of the objectives of documentation is to create a permanent record for posterity. To achieve this, graphic records must be preserved for future use. The preservation of documentation is an area of extreme importance that is now increasingly being touched upon and discussed. How can we ensure the preservation of our physical and electronic records? Consideration should be given to the production of hard copies of all electronic documentation, use of archival materials, proper archival storage facilities, and the continual upgrading of hardware and software.

As far as possible, documentation should be available for access and be easily accessible. The documentation system used for recording at individual sites should be briefly explained, including listing what exists, where the records can be located, what formats and methods of recording were used and how the information is organized, in order to help the next user of the documentation. Such a record of what information is available, where and in what format is termed *metadata*. To facilitate the management of the documentation of a site it is useful to create a database that lists all of the relevant documentation, a brief summary of their contents and where each record can be found. It is important to create a list of the components of the graphic documentation, indicating their physical location, such as original field hard copies, printouts from reports, CD-ROMs with digital documentation files, etc.

Interchange and dissemination of information

The AIC charter states that

> "documentation is an important part of the profession's body of knowledge and that conservation professionals should strive to give other professionals appropriate access."

Copies of all relevant conservation reports should be distributed amongst all significant parties and made readily available. Perhaps, in the age of rapid, worldwide communication, the Internet should be utilized for the sharing of information and encouraging multidisciplinarity.

WG2 QUESTIONS

Q1: ***Do we need standards? What should be standardized and at which level?***

The issue of standardization in graphic documentation was a keenly debated topic during GraDoc. It can perhaps be agreed by all that 'standardization' of some processes – thereby restricting creativity, flexibility, adaptation and evolution – is neither desirable nor achievable. Equally, it can also be agreed that some 'standards' – by providing a reference and facilitating understanding and consistency – can be useful, and are often crucial for effective communication.

Standardization in graphic documentation has been attempted in many different forms and at different levels, focusing on aspects of structure, categories, scales, legend and glossaries, symbols, etc. However, past attempts have all ended in unsatisfactory outcomes or are still in the developmental stages (e.g. see Chapter X in Jane Sounderland: *A collection of terminology sources for condition recording and graphic documentation*, 1999).

Why have earlier attempts at standardization been unsuccessful? Perhaps we have not yet taken the time to define what we mean by standards and standardization, nor have we outlined what we hope to achieve by creating such standards, nor decided upon the levels of standards we would deem appropriate. Problems also arise due to the different approaches taken with graphic documentation from conservator to conservator, personal preferences, the language factor, and the unique complexities of most wall painting sites, for which some feel it is impossible to apply universal standards.

At GraDoc there was agreement regarding the importance of defining and using a consistent nomenclature and terminology system, with the inclusion of a 'standard' legend applying to all graphic documentation generated as part of a specific project. The same consistency would be useful for sites with a vast number of wall paintings. In such cases 'site standards' for terminology and symbols would allow easier interpretation and comparison of data from the same site. For example, it was important to develop a glossary for the GraDoc Seminar (see Chapter 28) to create a common language amongst seminar participants and paper authors to facilitate communication and interpretation of information. It is hoped that the GraDoc document can be used as a basis for development of a common terminology – a standard – for graphic documentation in mural painting conservation. Existing sources of terminology are helpful as a guide and reference to develop a project-specific glossary; a good example is the Italian NorMaL standard glossary-*cum*-legend for stone conservation, which is used by Italian conservators as an initial reference when selecting terminology and symbols. However, because this glossary is general and limited to stone conservation, it is almost always necessary to modify it by adding project-specific terms to meet particular needs. Typically, it is convenient for workshops and conservation organizations to create their own terminology that can be adapted for each project, such as Getty Conservation Institute's "collection of terminology sources," or the mosaic glossary created as part of the mosaic project.

During discussion, it was noted that phenomena recorded and stored as digital information, can be tagged with a specific – standard – code reference, and visually presented in any number of colours or pattern combinations without losing that reference information.

Q2: *Do we need topographically correct base maps?*

Generally it is desirable, but not necessary, to have topographically correct base maps, i.e. without distortion and scaled, for graphic recording. The objectives of the graphic recording dictate the kind of base map required. If the graphic record is to be used, for example, to calculate the total extent of a phenomena for the purpose of costing a conservation programme, then there are obvious advantages in striving for greater topographic accuracy.

Q3: *How can curved surfaces be represented in 2-D output?*

Mural paintings are often located on complex and irregular architectural features, such as vaulting systems and domes. Recording of these curved surfaces is generally illustrated in 2-D, photographically or graphically, but this will inevitably distort the image. Hand-drawn line drawings, photogrammetric methods and the use of computer technologies that provide 3-D representation can provide solutions to the problem.

Using computer technology that can create and handle 3-D models can help in recording curved surfaces. However, the output and presentation of the data in hardcopy (i.e. 2-D) is always problematic, as distortion renders it difficult to find corresponding points on the paintings.

In most cases, a set of photographs, taken with line of sight at right angles to the painted surface, and all at the same scale, will provide a sufficient representation for graphic documentation purposes.

Q4: *What are the criteria for the selection of scales for the base map?*

The size and extent of the paintings, resources available and, as always, the purpose of the graphic record, determine at what scale one should record. The scale of the base map plays a role in determining the level of detail of the graphic record. For example, a high level of detail can be achieved on large-scale base maps (e.g. 1:5), but, as the scale decreases, so does the level of detail that can be recorded on that base map. When possible, it is useful to have base maps at different scales to record features that may require recording at varying levels of detail. For example, the location of *giornate* or *pontate* can be recorded on scale 1:20 photographs, while a detailed piece of information, such as the location of retouches *a secco,* may need to be recorded on a base map at 1:5 scale. When the base map is in digital form it is easier to produce base maps at different scales as the need arises.

Q5: ***What theme groups (or categories) could be used to structure graphic condition documentation?***

For each individual project it is necessary to select and define the essential theme groups to be documented in graphic form. The group compiled the following list of categories that might be documented in graphic form as part of a conservation project. These theme groups and their sub-categories are by no means complete, and it is not intended to provide a checklist for carrying out graphic documentation.

- ***Host structure or building information*** (This information often needs to be recorded on a schematic base map representing the host structure or building in context, in addition to the base map representing the art work. This may be in the form of a site or building ground plan or elevation (or perspective view). Sub-categories might be: building history; building condition; and materials of host structure or building.
- ***Art historical information:*** phases of painting, workmanship, etc.
- ***Previous interventions:*** treatments and materials used (location and extent).
- ***Techniques of execution:*** plaster joins, preparatory techniques, attachments, etc.
- ***Condition:*** stability of preparatory layers/paint layer, surface deposits, deterioration products, etc.
- ***Investigations:*** sampling location; environmental assessment information; liquid moisture survey information; environmental monitoring sensor locations, etc.
- ***Current conservation interventions:*** treatment testing; treatment (including methods and materials where appropriate).
- ***Documentation:*** comparative information from historical records (e.g. location of historical photographs, watercolours, etc); area documented with macro- and microphotographs, UV-IR photographs; and localization and identification system (include nomenclature and numbering of base maps sections).
- ***Monitoring data:*** control areas (to be regularly checked) and location of changes (new damage).

Note: features or items present on the entire surface (e.g. dust, fixative applied during previous intervention, biocide application, etc.) do not need be represented graphically but can be described in writing on the same map.

Q6: ***How can one ensure a level of consistency in on-site recording?***

Consistency in recording depends on the knowledge, perception, training, experience and number of the people carrying out the recording (i.e. larger groups = less consistency). It is advisable to designate a conservator with experience in documentation within the conservation team to coordinate and supervise the recording. If possible, conservators with suitable experience should carry out the recording, and appropriate training should be provided for less experienced team members if necessary. Planning and overall management are essential at this stage. One of the most useful tools to ensure uniformity in recording is the glossary, naming and describing the features to be recorded. Whenever possible, a visual glossary is recommended, with macrophotographs or illustrations identifying the features to be recorded.

Visual glossaries are being used with increasing frequency to promote clarity and consistency during the recording process, especially when more than one person is carrying out the data collection. These visual glossaries subsequently aid interpretation of information and facilitate communication.

Some features are more difficult than others to univocally define, e.g. areas of detachment, and are more prone to inconsistency, as the recorded area depends very much on the perception of the recorder. It is important that when there is a doubt, members of the documentation team can refer to a documentation supervisor for clarification. In such cases, specialist examination, where possible, may aid in the examination and recording process. It is important to note areas where there are uncertainties, stating clearly that the areas documented are approximations and not necessarily an accurate depiction of the actual situation.

The working group also considered what core-data might be, usefully, included to promote consistency and clarity across documentation projects. The following list is the initial result of these discussions:

- Explanatory title, project name and location.
- Orientation, location of painting within a building or host structure (ideally including plan).
- Scale (linear scale bar).
- Name of conservation firm/person recording.
- Date of recording.
- Reference number (Base map section number).
- Features or features recorded, and corresponding graphic symbols or colours.
- In addition, the report might include explanatory written notes specific to the layout, explaining what the graphic documentation is describing, the methods of recording, and constraints and conditions experienced during the recording process.

If the recording is made on paper or transparency, the legend that identifies the graphic symbols is best included on the same sheet as the information, making each sheet self-explanatory.

Q7: ***How can we graphically represent different intensities of the same phenomenon?***

Occasionally, there may be the need to distinguish the intensity of the same type of decay (for example: light, intermediate or heavy). In this case, to ensure consistency, it is important to have a clear definition in the glossary of what is to be recorded, i.e. how one defines light, intermediate or heavy. Once the areas with different intensity are defined, there are several options for graphically representing the situation. For example, the same kind of graphic symbols or patterns with different density can be used (e.g., different sized dots, or different density of dots, or different intensities of the same colour).

Q8: ***How can we indicate boundaries of features?***

Some features, such as lacunæ, can be graphically recorded by a closed, well-defined shape; while others, such as areas of detachment and salt efflorescence, have less clearly defined area boundaries.

When recording in hardcopy (i.e. non computer-aided recording), features that do not have boundaries are typically indicated with a graphic pattern that fades away at the edges, so that no concrete boundaries are indicated. However, when producing graphic records in digital form, this issue becomes more relevant because the actual area of the features must be defined with a border for the software. One way of addressing this problem is to use a solid line for clearly defined areas and a dashed line (or no line) for areas without clear boundaries.

Q9: ***How can we reduce the loss of accuracy from the initial record through the documentation process to the presentation?***

Loss of accuracy from the initial record through to the presentation of graphic documentation can be reduced by having a supervisor take part and follow all steps of transfer and translation of data, and by minimizing operations *ex situ*. The fewer steps there are, the fewer opportunities for error, and therefore more chance of retaining the original accuracy. For example, direct *in situ* graphic digital recording is ideal to reduce the number of steps. Direct recording is not always feasible, and an alternative is to record each phenomenon (or a small set of related features) on transparencies, with appropriate markers and scaling, and scan them in digital form. In this way the different layers can be viewed with the base map and together with other overlays.

The time and resources required for this component depend on how well the data collection phase was conducted. Usually, a small team of conservators conducting graphic recording can easily produce organized material, while a larger team's results require more effort to make them uniform.

Q10: ***What are the pros and cons of using black-and-white symbols versus patterns or colour?***

Graphic documentation can be prepared and presented using a single tone on a contrasted background (typically black on white), using monochromatic-scales such as grey-scale, or in full colour. Generally speaking, it is easier to indicate and distinguish between different phenomena using a combination of patterns, solid or semi-transparent fields in varying hues and tones. Complex representations of observed phenomena, requiring multiple superimposition of information, are clearly more restricted in black-and-white. However, this is not to say that black-and-white graphic documentation cannot be entirely sufficient and appropriate for the task. While certain phenomena lend themselves to clear demarcation by outline, with other conditions, such as delamination, this can give a misleading impression of accuracy. In general, colour documentation is very user-friendly and practical in both the recording phase and in presentation. It is more visually explicit, as colours can easily be associated with condition. Additionally, using particular colours (e.g. red for the most serious condition) enhances the graphic message. At present, black-and-white documentation can be copied and stored more easily and at less expense than colour documentation.

Q11: ***How should documentation be archived?***
Hardcopy on durable paper must be stored in a proper, dry environment. Transparencies, acetate overlays and photographs also need proper storage. Colour markers on transparencies tend to fade with time. For long-term preservation, they need to be copied onto durable paper. Soft copies (i.e. diskettes, CD-ROMs) must be regularly backed up and transferred in latest format. It is advisable to have more than one copy of the graphic documentation and to store it in different places.

For easy access, it is necessary to have a clear list of the graphic documentation produced, indicating where it resides. This information should be available, and relevant parts of the documentation should be disseminated (published).

Working Group 3

DIGITAL GRAPHIC DOCUMENTATION AND DATABASES: CRITICAL EVALUATION AND COMPARISON WITH CONVENTIONAL METHODS

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APPROACH

GraDoc's Working Group 3 was composed of 10 conservation specialists with considerable knowledge and experience in using computer technology for the 'heritage recording and documentation' of wall paintings and other decorated surfaces.
Towards the end of the seminar, it was recommended by many GraDoc participants that, due to the limited time available, the output of group sessions could only provide a 'preliminary discussion document'. With this in mind, Working Group 3 addressed the issues provided by restructuring some of the headings, and by expanding each heading with a list of possible answers that should be developed further, at a later date, into a Framework Document.
The following text is then an accurate representation of the themes discussed during the meetings, with, in addition, an expanded section of topics requiring more detailed explanations.

Note: Additional information to the following summarized results of this working group are given in the attached WG3 annex; all points for which such information exists are referenced with a number in brackets. For technical terms we also refer the reader to Chapter 28 – Glossary of Terms used for GraDoc.

1. *What are the pros and cons of using computer-aided graphic documentation?*

Pros:

- Data is flexible (1)
- Possibility of using layer system and overlay (2)
- Creation of image mosaics and collages (3)
- Zooming to different levels of detail (4)
- Easy to output in different scales (5)
- Can more easily correlate and integrate various categories of data (6)
- Data can be easily reproduced (7)
- Facilitates data sharing (8)
- Distributed database, mirroring, easy to insure most secure storage procedures (9)
- Facilitates creation and dissemination of standards (10)
- Wide range of software available in the market, everyone can choose what is really needed
- Matured GIS can be base of multimedia information system (11)

Cons:

- Cost of equipment (investment risk – issue of updating hardware and software; fast turn-around of software versions – (which can mean improvements too)) (12)
- Training is required, as the process becomes more complex (13)
- Plug and 'pray' (...it is sometimes difficult to configure / operate the equipment, computer failure ...)
- Possibility of data loss by lack of sometimes expensive secure data storage procedures
- *Long term data update (14)*
- *Lack of user-friendliness in some software (15)*
- Difficult to select the graphic software required without specialists' advice
- *Incompatibility between hardware and software (16)*
- Encourages non-selection and accumulation of copies of / unnecessary data
- Raises expectations of data collection and presentation, therefore requires the availability of specialized personnel
- May convey an unjustifiable sense of accuracy and completeness.

2 *What are the pros and cons of in-situ computer-aided recording?*

Pros:

- Direct data input by conservator, with the possibility of quality control of immediate results
- *Saves the step of data transfer/copy to digital format (17)*

Cons:

- Site constraints: adverse environmental conditions (dust, heat, sun, humidity, rain, etc.), lack of power or power failure, scaffolding vibration
- Mobility/Portability (18)
- Transport, security and insurance
- Enhances requirements for verification procedure

3. *Other computerized tools and technology applicable to conservation documentation*

- Thermography
- Multispectral imaging
- 3-D laser scanning
- Photogrammetry
- Digital imaging
- Laser surveying
- Environmental condition recording
- Radar
- Holography
- Ultrasound

This list could be much longer. The idea is that there are many other computerized tools that enhance the potential for electronic data integration.

4. *What are the criteria for choosing software and corresponding hardware?*

- Adequacy to the purpose
- Knowledge to operate
- Availability of technical support
- *Standardized/sustained software (19)*
- *Cost (20)*
- User-friendliness
- Interoperability between software systems/platforms (21)
- GIS functionality criteria

5. *What are the pros/cons of currently used software?*

A complete answer to this question is beyond the scope of this document.

There are mainly two types of software systems that can currently provide useful functionality for achieving digital graphic documentation: raster-oriented software systems and vector-oriented software systems. While the first type focuses on raster data processing, the second focuses on vector data processing. In other words, raster-oriented systems are mainly dedicated to images while vector-oriented systems mainly deal with line drawings. Of course, there are a lot of software products on the market; the table presented in the annex to this document (see: comment 20) shows just a few of them.

6. *What are the recent advancements and future trends?*

Advancements:

- Increased compatibility between software systems
- Friendliness, through intuitive Graphic User Interface (GUI)
- Raster-Vector integration
- Digital capture of documentation base maps
- Inclusion of spatial information
- Faster computers
- Higher capacity storage devices at a lower cost
- Compression algorithms (22)
- Flat screens

Trends:

- Open systems (23)
- Standardization of components (24)
- 3-D imaging and Virtual Reality (VR)
- 4-D (25)
- Multimedia
- Wearable computers (26)
- Voice recognition
- Affordable photogrammetry
- 3-D copying (27)
- Stereo 3-D vision on PC
- Total mobility/portability (data broadcasting)
- Increased secure data transfer

7. *Is the use of computers cost effective?*

Pros:

- Speeds up operations, saves time
- Data accessibility
- Digital data representation may be of higher value (in storage) than the corresponding hardcopy presentation
- Reproducibility
- Long-term cost effectiveness

Cons:

- Wastes time (28)
- Output (hardcopy, i.e. special paper) is more expensive
- Investment risk

8. *What levels of digital documentation can be used together with manual methods?*

A digital system can be used to store, retrieve, manipulate and present manually recorded data by means of scaling, scanning, spatial referencing, rectification, and insertion/incorporation/ combining. Generally, there is no restriction concerning the levels of digital documentation that can be used with manual methods.

9. *Should we create a new type of expert, a documentation specialist? (in an ideal situation)*

"Yes, this is absolutely necessary."

10. *What is the role of the documentation specialist and what knowledge and skills does he/she require?*

Note: the next generation of conservation specialists should be computer literate

Role:

- Assist conservation specialists and heritage managers
- Make systems effective
- Data exchange
- Make the data accessible, available
- Participate in application development (29)
- Divert the conservation specialist from the computer back to the object (30)

Knowledge or Qualifications:

- Computer literate (with regard to equipment)
- Software/customization (31)
- Conservation understanding

Skills:

- Communication ability
- Attitude/flexibility in the job
- Solve technical problems (troubleshooter)
- Communicate / interface with programmers

11. *What is the role of the conservation specialist?*

- Should be the manager/coordinator
- Have a general understanding of the possibilities of digital tools
- Responsible for defining objectives, scope and approach
- Ensure resources for equipment upgrade and replacement of hardware and software
- Should cooperate with the documentation specialist
- Responsible for coordinating / linking documentation to interdisciplinary conservation activities

12. *How can we ensure current and future accessibility of information and take into consideration long-term compatibility of hardware and software?*

By:

- Ongoing maintenance of data (32) (see also M. MacLean and B.H. Davis. 1999. *Time and Bits. Managing Digital Continuity*. Los Angeles: Getty Research Institute)
- Ongoing hardware and software upgrades and maintenance
- Choosing standard (documented, fully described) formats (33)
- Verifying with national archives (hoping they would take on this task)
- Access to 'data recovery' services (i.e. a service specialized in translating 'old data formats' to work with 'current data formats')

13. *What are the different types of digital data?*

The main four types of digital data used for digital graphic documentation are:

- Vector data
- Raster data
- Three-dimensional data
- Textual data

14. *How should data be captured, structured, archived and accessed?*

Captured by using:

Rasters:

- Scanners (flat bed and/or film)
- Digital cameras
- Digital video cameras
- Video camera (with hardware to translate the video to digital signal)
- Infrared cameras, radar, multispectral sensors, etc.
- Corresponding software technologies

Vectors:

- Total station, laser theodolite (34)
- Digital tablet/mouse

Text/input devices:

- Keyboard
- Scanning/OCR (Optical Character Recognition)
- Microphone / voice recognition

Structured by:

- developing a logical file naming and directory structure (35)
- accompanying data with metadata (description of your data, or data about data)
- developing network (Intranet) standards
- means of relational databases
- developing and applying guidelines

Archived by:

- avoiding duplicate information (redundancy)
- backing up your data
- using a dispersed system of data storage (36)
- storing original files in ASCII format (37)
- avoiding formats that induce loss of information (38)
- promoting the use of Postscript files for publishing
- accompanying data with metadata
- including software that allows graphic data preview

Accessed by:

- ensuring that the organization has a data manager
- making data easily accessible
- safeguarding data

15. *How can curved surfaces be represented in 2-D output?*

- By defined planar projection
- By simulation/Quicktime 'virtual reality'
- By unfolding

WG3 ANNEX

Additional information relating to the summarized results of WG3

These additional comments and clarifications were kindly prepared by Florian Petrescu to facilitate the understanding of the document. They are mainly addressed to readers who are less familiar with computer technology.

(1) Digital data and, particularly, graphic digital data can be easily modified at any moment during the process, while earlier versions are (systematically) saved.

(2) This is the digital correspondent of using traditional transparencies over a photograph or a line drawing base map. Thus, within the context of digital graphic documentation, a layer is a (thematic) subset of digital data selected on a basis other than position, for instance by subject; usually, a layer might consist of a recorded phenomenon. An overlay is a set of graphical data that can be superimposed on a base map. Sometimes it is used as a synonym for layer, especially in those cases when the information is grouped according to a subject or an attribute. Due to the digital techniques, layers and overlays can be created, retrieved and presented in any possible combination; in this way, ease of the study/highlight of interactions is ensured.

(3) A mosaic can be defined as an assemblage of overlapping images (photographs) whose edges have been matched to form a continuous pictorial representation. When using digital technology, the mosaic of several images is a stand-alone image itself, while a collage is also an assemblage but consisting of several individual images; a collage is not a stand-alone image itself and can include non-continuous graphic details. Digital techniques enable the ease of creation and manipulation of image mosaics and collages. Thus, the use of imagery (photographs) as base maps becomes technically easy to achieve.

(4) There is no upper limit for zooming in, but one must take into account the resolution of the image. Thus, if an image has a resolution of 1mm, then 'zooming in' to a greater detail than 1 mm will lead to revealing the pixels (in this case, squares of 1 mm by 1 mm) of the image; there is no possibility of getting information at an arbitrary high level of detail; the highest level of detail is defined by the image resolution.

(5) Generally, for digital graphic data, there is no restriction regarding the scale of the output, be it a hardcopy or on-screen. From this point of view the conservator will spend practically no additional time for producing the same graphic documentation at a different scale. Nevertheless, one should be aware that there are some 'logical' restrictions. These restrictions are related to: a) the type of digital graphic data; b) the resolution of the digital data; and c) the accuracy of the digital data. Scale and accuracy of data are in a close relation: for instance, if one makes a graphic documentation at the scale 1:20 then the (computed) accuracy of the 'output' should be 4 mm. Therefore, the measurements on the wall should be at least as accurate as 4 mm.

(6) This point relates to software which allows the correlation and comparison of data from different areas of investigation and of different format (e.g. text, vector and raster) with the possibility of creating new information.

(7) Digital graphic data can be easily copied onto various magnetic media or transferred between compatible computer systems. At the same time, digital graphic data can be easily plotted/printed at any point in time.

(8) This is a general advantage of using computers and information technology. Provided that compatible computer systems are available, the dissemination and accessing of digital (graphic) documentation becomes an easier task. Of course, the Internet may become an increasingly valuable tool for sharing data. Also, current advances in information technology allow design and implementation of large-scale (e.g. national) databases that provide wide access to users in different geographic locations.

(9) Distributed database management systems and mirroring are two of the most important information technologies required in large computer applications (at national, regional or

international level). Specific procedures including the use of passwords and keycodes can provide a way to avoid unauthorized access to data. At the same time, systematic creation of backups and/or archives on magnetic media reduces the risk of data destruction.

(10) Information standards are required whenever systematic exchange of information takes place.

(11) GIS provides a lot of valuable tools which can assist conservation specialists in decision making. GIS can put all possible types of information together and, moreover, can structure all that by referring it spatially. Because of its ability to treat all types of information, a GIS can ensure the use of multimedia systems.

(12) The use of information technology has several characteristics that must be taken into account. One of the most important ones consists in its extremely fast pace of technological development. For instance, when purchasing a computer, one must be aware of the fact that the generally accepted (e.g. within European Union research and technological development projects) depreciation period is 3 years. When referring to software, the situation is more dramatic, because software purchased 'today' will be already outdated 'tomorrow' (i.e. a new, better version comes out). When using Information Technology (IT), both the initial (purchase) costs and the maintenance (upgrading) costs must be taken into account. If maintenance costs are not budgeted, the investment can be a waste of money.

(13) IT tools require training at a certain basic level and continuous professional development. Training becomes a critical problem when specialized professional knowledge is needed. Generally, for certain specialized and complex IT tasks, the specialist cannot be replaced.

(14) How to use digital graphic documentation over 20, 50 or 100 years? Obviously, no one has experienced that yet. What hardware and software will be available at that time? Obviously, nobody can possibly know. Nevertheless, one way of 'keeping the data alive' is to systematically convert them into new formats, in accordance with the technological 'state of the art' at the time of conversion. For further issues related to the 'long-term persistent data,' refer to section 3.6.

(15) The current trend in the software industry is to create products having user-friendly interfaces. Nevertheless, there are cases when a special design and implementation effort is required, known as 'customization.'

(16) In most cases, this type of incompatibility appears when the hardware was purchased before deciding what software will be used. To avoid such situations, the hardware must be procured based on the minimum or recommended configurations imposed by the selected software.

(17) When digital data is entered directly to the computer (i.e. using tools such as digital tablets, cameras, theodolites, 3-D laser scanners, etc.), field work should be more cost effective. If traditional recording methods are used, the transfer of manual data into digital format takes time and inevitable information loss happens. This is due to the fact that data conversion itself can be a rather complex process that cannot 'capture' all the original information. Thus, depending on the type of original data sources (e.g. photographs, line drawings on transparencies or on paper) specific equipment and software are required, specific formats are to be selected, and, sometimes, specialized personnel must be involved. This specialist may not be familiar with the conservation project, thus creating possible sources for errors in the data transfer.

(18) Sometimes, it is not so easy to move the equipment from one place to another.

(19) Within the context of the Working Group 3 document, when related to software, the term 'standardized' should be rather considered as 'most used' on a certain market. For example, in referring to PC computers, 'Windows' is such a standard. 'Sustained software' refers to those software products that are systematically updated by their manufacturers (software providers); usually, in such cases, the software providers offer technical support, training and software maintenance on a regular basis.

(20) Examples of software types and their costs:

Cost (US$)	0-500	500-2000	2000+
Raster	Shareware	Adobe Photoshop	DVP
	QuickTime		
	QuickTimeVR	DVR	
Raster oriented	Shareware	Raster to vector (Hitachi V-Image, Raster Edit)	
Raster and vector oriented (graphic/internet)		Macromedia Freehand	ERDAS Imagine
		Micrografix Designer	
		Adobe Illustrator	
		CorelDraw	
		Adobe Golive and Page Mill	
		MS Front Page	
Raster and vector oriented (desktop publishing/internet			Adobe Pagemaker
			Quark XPress
Vector oriented	Shareware	MapInfo	AutoCAD
	AutoCAD LT		AutoCAD Map
		Atlas GIS	CAD Raster
		ArcView with Spatial Analyst	ArcInfo
			Microstation
			MGE Intergraph

Note: This is not an exhaustive list of software and needs to be completed and updated at least yearly.

For example, it seems that AutoCAD is still at the basis of most computer-aided graphic recording. Photoshop, Designer, Corel Draw, Freehand and Illustrator can be used to create a complete condition recording. Using Pagemaker or Quark Xpress is a possibility to combine text, raster and vector information as a final document for archives (without database interface). Desktop GIS software (such as ArcView GIS) seem promising solutions for digital graphic documentation.

(21) When referring to software systems/platforms, the term 'interoperability' means that the software systems are built in a modular fashion using standardized components as building blocks. Thus, instead of large, amorphous software packages one can see 'toolboxes' that can be built into larger systems. In this way, components from one particular system may be used within another one.

(22) Algorithms that encode data in such a manner that the overall volume of data is reduced.

(23) Within IT, the approach to openness is to agree on data description standards that ensure that data can be transferred between systems without loss. For instance, an 'open system' should focus on the ability to import and export different data formats while developing capabilities to directly read third party data structures.

(24) Both software and hardware providers encourage the use of industrial standards for the design and development of new products.

(25) The fourth dimension is time. In this way ease of change detection is enabled.

(26) Computers that are small and that can be carried in hand (palm-top) / on a belt (strapped portables) / etc...; 'Wearable' computers, in particular, refer to systems that have tiny monitors that can be mounted on an eye-glass frame, and keyboards that are attached to one's wrist, while the main unit is mounted on a belt worn by the operator.

(27) Devices that provide the possibility of making 3-D / replicas of an object.

(28) Some digital operations may take more time than traditional manual ones. For example, creating digital basemaps may take more time than drawing them by hand. The advantage, however, resides in the fact that multiple original copies at disparate scales can then be produced from the digital copy.

(29) Application development refers to the design and implementation of software intended to solve a particular set of problems.

(30) The activity of the documentation specialist should allow the conservator to focus on conservation.

(31) The documentation specialist should be able to assume the use of all relevant software for documentation purposes, including software customization if needed. Also, the documentation specialist will take care of the 'continuous updating' of software (maintenance).

(32) This refers primarily to the issue of 'long-term update' (see comment 14). Nevertheless, it is not clear who should be responsible for financing the operation, which is mainly conversion of format and who should actually achieve all the technical operations required. For the time being, these are still open questions. It is important to note that a similar problem occurs in cartography: the digital maps must be continuously maintained. In this case, the maintenance costs are supported by the editors or publishers.

(33) Generally, it is recommended that digital data should be stored in a format for which a complete published description is available. In this way, no matter what software is available in the future, programmers will be able to create specific pieces of software able to 'read' the data, and, consequently, to convert it into whatever format is required at that time.

(34) These are surveying instruments that measure angles and distances.

(35) A 'good' name for a file is a name that helps the operator to remember immediately what is the content of that file. A 'logical' directory structure consists in organizing the files in a hierarchical manner so that retrieving a file and the place where it is located becomes an easy task.

(36) Generally, it is recommended to make several copies and to keep them in different places / computers / buildings. In this way, the risk of data loss is minimized.

(37) The ASCII format is one of the most popular digital standard formats. Using it for alphanumeric data storage enables data exchange between platforms.

(38) Generally, digital formats that need a smaller storage volume imply, inevitably, a certain loss of information.

1 The following is a working definition used for the purposes of GraDoc; other definitions have been formulated by, among others, AIC, CIDOC and CIPA.

2 The purposes of documentation have been articulated in a number of charters and guidelines of professional conservation bodies; for example, Athens 1931 (A, 7, c), Venice 1964 (16), Burra 1992 (28), ECCO 1993 (10), ICOMOS 1996 (Principles for the recording of monuments...), and UKIC 1997 (Rules of practice, 1.1.4). An exhaustive definition (with descriptions and commentaries) is provided in the AIC Guidelines for Practice 1996 (articles 24-28) [http://aic.stanford.edu/pubs/ethics.html].

3 Preservation of digital media is highly topical and both information and views will change rapidly; a current site with useful links is: http://www.longnow.com/10klibrary/TimeBitsDisc/links.html

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TRANSCRIPTION OF DISCUSSIONS

This document was produced from tape recordings made during the seminar. It aims to provide access to additional information, clarifications and comments contained in debates following the presentations of the papers. In most cases only selected parts of the discussion were transcribed.
In addition, an extract of an interesting discussion on the subject of "minimum acceptable practice, for producing a correct graphic documentation of mural paintings" is given. This issue was debated during the plenary session that followed the first meeting of the working groups.
In order to preserve the 'freshness' of the dialogues, they were basically left in their original version. Only minor language editing was done to ensure clarity.
Unfortunately, due to the poor quality of the voice recording, the discussions of day 4 of the seminar, held at the Consiglio Nazionale delle Ricerche (CNR), Area di Ricerca di Roma del CNR, [Italian National Research Council, Institute for Technologies applied to Cultural Property (ITABC)], at Montelibretti near Rome could not be processed.
This document is meaningless if not read in conjunction with the papers.

Discussion following Walter Schudel's presentation:

LEITNER: You say that a work of art does not speak for itself and what you are asking for is exactly that the work of art speaks for itself and gets into relation which each person looking at it telling what he can find there without needing any additional documentation. I think we have to separate what we need for the conservation of it, which means, to understand what is behind it, not to describe the message. For documentation I could think of making an artistic copy of the work of art with the result of having a document which is very close to it but far from what we expect from conservation documentation, for which we want to record measurable facts. So I think to understand that you ask for a general respect of the work of art – that is very important – but you should not use this argument to be against documentation. Documentation will pay respect but is another level of dealing with a work of art.

SCHUDEL: yes you need to document ... there is no contradiction. The point I wanted to make is to stress the fact that what you document is not reality – it is already interpretation.

PALUMBO: You mention time as a very basic requirement for a good documentation. I wonder whether a good documentation can still be prepared with little time available.

SCHUDEL: The first thing is conservation and understanding of the work of art. If I don't have the feeling to understand a work of art, I will not touch it. Only afterwards I can think of documentation, but I don't start with documentation.

CATHER: Does the process of documentation help you to understand the work of art?

SCHUDEL: Yes, I think so. First I try to look what there can be between the work of art and me. This process leads to ideas with many things still remaining unclear. When I start to document, to write or to draw I have to be more precise in my ideas.

PIQUÉ: It is my experience that to do graphic documentation we must start with defining the features or phenomena we want to document (i.e. create a glossary). While we go through the process of recording we are able to understand the work of art better and define specific phenomena better. It is a dynamic process.

LETELLIER: In architectural conservation, one of the comments and criticisms I got from architects and archaeologists when I tried to promote the use of new technology to them to do their recording quickly and more effectively, is that they were losing contact with the object. The technology became an interface in doing this work for them. They had a good point, because part of conservation activity is to understand the object and we need to be in contact with the object to understand it. There must be good dialogue between the conservator and the people doing recording. The conservator could tell the recorder what he's looking for, if he (she) has a preliminary understanding of the object. Then the recorders can do the recording and, at the end, the conservator will go back to the object with the record in hand to verify/confirm some assumptions.

LEITNER: We have to distinguish between investigation and documentation. The first is to get knowledge and the second to process this knowledge into documents which will allow us to transfer this knowledge to others. The documentation specialist cannot replace the conservator in the investigation phase.

PIQUÉ: I think documentation is one of the tools of investigation. Many people mean different things by 'documentation'. Let's remember the GraDoc working definition of conservation documentation: information acquired over time, which constitutes a knowledge base.

SCHMID: For this seminar we decided to focus on conservation documentation, which is the documentation necessary to preserve a work of art. What Walter Schudel touched is more to do with the documentation of the spiritual or artistic values, an aspect that might not be included in conservation documentation. There are other types of documentation, such as the one used by archaeologists. Their aim is to create the closest possible model of reality they can, for instance, document a layer, which will be irreversibly lost in the process of excavation. So the only thing that will remain is the document. This is not the type of documentation we are discussing on this seminar.

SCHUDEL: You cannot do conservation, in our case of mural paintings, without changing it. You will change its aspect in one or the other way and you have to choose in what way you want to change it. Therefore you have to make documents.

CASCIU: It is not possible in the beginning of a project to know what is necessary. For complex projects it is necessary to have a broad range of documents. It is difficult to separate conservation documentation from other types of documentation.

SILVA: It is important to set our final objectives. We have to approach in parallel and then make a final synthesis. Each specialist will collect his type of information. All these in-puts are brought together.

Discussion following Konrad Zehnder's **presentation:**

CATHER: It is useful that you have emphasized the uncertainty about what we can understand of a painting and the issue of documentation being a process. The question is – how can we convey that uncertainty? How do we make clear that we are presenting partial knowledge, an evolving knowledge, an incomplete understanding?

ZEHNDER: In a scientific way we can only get the evidence of a process. All this is both objective and subjective. However, in case we have observed and reflected on what we saw and recognized that we came to a useful explanation, we can be satisfied. Although, in a scientific sense, we can never be sure, in practice we can go on, being aware that we will have to correct our knowledge.

SCHMID: Konrad Zehnder's contribution also touches the aspect of monitoring, an important aspect of documentation and investigation. It is always essential to know whether decay is still active and how fast it is progressing. Graphic and photographic documentation can be efficient tools for monitoring.

LEITNER: To me a very important aspect of your presentation was that documentation is a process and has a result. I would like to add that it is a continuous process and that we are working in it.

ZEHNDER: You are right. It can be finished for a particular purpose. Sometimes it must be finished. But in fact it is an ongoing process.

SCHMID: There is a problem on how to name a phenomenon. As long as we don't know what it is that we see we should just describe the appearance. For example we should only speak of a 'whitish veil' until we know whether it is salt efflorescence, a decayed fixative or a microbiological growth causing it.

ZEHNDER: It is a scientific method to distinguish strictly between the field of observation and the field of interpretation. Of course, observation is also interpretation. But it is very important to be in the field of observation when we do condition assessment.

SCHUDEL: Concerning the never-ending task: I think this also applies to inventories.

Discussion following Sharon Cather's presentation:

WONG: I would like to follow up this whole idea of time. I think that basically there are two general periods of *use* for documentation: the current period of investigation and treatment and its potential future use for monitoring purposes. I think it is important to make a clear distinction between these very different uses of documentation.

PALUMBO: As a documentation specialist, whatever that means, I agree with some points you raised and I strongly disagree with others, both from a theoretical and technical point of view. I agree that we need to record what is really required for documentation and it is true that we do not always use the data that we collect. I disagree when you say that graphic documentation is always subjective and never objective. That would mean that nothing is objective in the world. We should really define that. You refer it to the transformation of phenomena into graphic signs, but there are different ways to represent a sign. You also said that documentation is subsidized because it is not defined. That is probably true but it is up to the conservators to decide. The documentation specialist can only assist to find a process. This is something we are trying to do at the GCI. We are trying to work towards a method and a process that is going to solve the gap between what the documentation specialist can advise about procedures and what the conservator wants and requires. You touched the important point of accuracy, which is also what is driving up the costs. It is certainly true that we do not need certain accuracies for certain purposes. It is important to define at the beginning of the project what you want to record and what accuracy is required. You also said that it is not possible to have paper out-put anymore. I think it is just the opposite. With electronic graphic documentation we have a lot of paper out-put, much more than we had in the past. It is important to have paper copies, because electronic media do not last as long as paper.

LEITNER: I want to underline that as a conservator not only do you have to subsidize documentation but you have also people asking: how can he subsidize this? Where does the money and time come from? This puts you in a very bad position. You said we can save time if we leave the processing of data to someone else. I think we should ask the documentation specialist to provide us with the technology that allows us to put immediately the data to archive during the observation. So much information gets lost because we do not know where we can put it in the moment. You write it on a piece of paper or you put it into the computer, but you do not know exactly where to address it. It is important to define these addresses, to define tools that allow you to put information immediately in the right place. This is a point where computer programmes such as GIS can probably help. It is also important to store information in a central archive where it is readily available for use. Such an archive, from an economic point of view could save a lot of resources and avoid duplication. I think that presentation is the least important thing in documentation and can be left to someone else (i.e. the documentation specialist). Presentation is often seen as the most important part; it is for what people judge you for. Again, also for presentation, computer-aided systems might allow for an increased involvement of the conservator in the decision on how the message should be conveyed. I hope this meeting will give some more directions on computer programmes that facilitate both, the archiving of data and their presentation. Where one can save money must be discussed with the institutions in charge of information management.

NEGUER: I think we should make a distinction when we talk about information or documentation management or graphic documentation. If the new technology helps me to increase the objectivity and the quantity of objective information I agree to use it. But if the new technology aims to increase the interpretative means of documentation I have a problem. For me all documentation is a subjective, interpretative process. With regard to manpower, if I do not have conservators or computer specialists what can I do? Where do I have to put the money today is a big problem for me. Normally the money goes to computers and sometimes to conservation specialists, who are responsible for the accuracy of the documentation. Because any diagnostic mistake made by an insufficiently qualified conservator is infinitely bigger than any mistake due to a wrong input of data on behalf of the computer specialist.

OREA MAGAÑA: We are doing documentation since over 10 years with photographers and architects and we found it very hard to explain to them what we want from their drawings or photographs. Often they show you their photos, which do not explain anything of the damage they want to document. We found that drawings are sometimes more useful than photographs but we need both. It is very hard to explain to a person who is not a conservator, which photographs are good and which are the best processes to get a good documentation of the problem.

Discussion following Nimal de Silva's **presentation:**

LEITNER: What I did not understand. These copies are displayed in a museum to show these paintings to people who cannot go to the site?

DE SILVA: 95% of these paintings are in storage only about 5% are on display.

CASCIU: Do the traditional artists who make the copies also use traditional painting techniques?

DE SILVA: No, they use oil on canvas.

CASCIU: But is there any research on the original techniques?

DE SILVA: In some cases the same traditional families who did the paintings are still alive. They still have and use all the traditional recipes for making mural paintings. We were very happy to involve them in the project and to get this knowledge from them.

WONG: You mentioned the bomb damage you had at the temple of Kandy. Could you explain how useful each of the three types of documentation (copies, photographs, graphic documentation) was for the reconstruction/restoration of the heavily damaged wall paintings?

DE SILVA: We did not use the artistic documentation for restoration. What was relevant in this case was the photographic and graphic documentation. However, unless in the case of the Temple of the Tooth [Kandy} where we had to pull out all the documents we had in order to be able to put fragments back in the same position, I have my doubts that the enormous amount of graphic documentation we normally produce will be often used in the future. It is an enormous amount of information and we thought to put it into a computer to facilitate access and to achieve our objective, which is to use this documentation as a management tool.

PIQUÉ: In general, how does the graphic documentation influence the actual treatment on the wall paintings?

DE SILVA: The conservators prepare their own documents based on the grids and everybody uses the same key according to the ICCROM formula. So everybody knows what is 'powdering' or 'flaking.' We have a standard for the project.

LEITNER: You just mentioned the ICCROM formula. I did the ICCROM course 21 years ago. I know that the formula is based on what the Moras did and published in this field, for example the layer system. ICCROM had a very important influence on many countries where these symbols and methods are used.

SCHMID: Maybe I should comment on this because I think there is quite a misunderstanding. It is true that important methodological principles based on the research of the Moras and of the *Istituto Centrale per il Restauro* were disseminated through ICCROM's International Course on Mural Painting Conservation. However, ICCROM has never developed or promoted any standard glossaries, legends or symbols for graphic documentation. We have established different project-related legends for the different training worksites organized within the activities of these courses. In some cases, what happened was that students used these legends when once they returned to their home countries, because maybe they liked them or found them practical. However, in cases like Sri Lanka, where a great number of mural painting sites are managed by the same administration, standards can be very useful – it make sense to establish more broadly valid, territorial standards in order to produce comparable data.

DE SILVA: We have more than 20 professionals trained at ICCROM who all follow the same formula, adapted to our needs.

SCHMID: If by 'formula' you mean 'methodology' I agree.

BUZZANCA: The Italian Standardization Commission NorMal as a basis to develop a standard for graphic documentation used a number of unpublished documents, mainly legends used in worksites of the ICR or ICCROM, like the Scrovegni Chapel or the Oratory of the Forty Martyrs. I would like to underline the latter, a document prepared by D. Cavezzali for the worksite activities of the International ICCROM course on Mural Painting Conservation (MPC), organized from 1992-96. It includes a structure of thematic maps and a legend restricted to phenomena recorded on this particular site. It was a good starting point for a possible computerization.

Discussion following Francesca Piqué's presentation:

CATHER: This overall structure – which is very coherent and complete – is it normally the way you document when you expect to intervene? So you would not do this if you were just going to make an assessment of condition?

PIQUÉ: No, we do this in the assessment phase whether or not we will intervene. In fact some of our projects at the Getty Conservation Institute are limited to condition assessment.

SCHMID: There were two very interesting technical details that I share very much from our experience. First, the use of photographs as base maps. In graphic documentation of mural paintings, photographic base maps are of enormous help because, compared to line drawings, they provide many more visual references, facilitating the location of recorded items. Especially at a smaller scale, this becomes a big advantage. If one of our aims is to increase accuracy, then photographic base maps can help. The other point is the use of visual glossaries. You don't just have a legend where you name the recorded phenomena and add the symbol with which you represent it, but you also provide a small photograph or a series of them showing examples of the specific phenomenon and a brief description. Because what is 'flaking' on one wall painting could have a different morphology on another. To make things clear to everybody – to those doing the recording and those who use the record – is very important. A very delicate step in the graphic documentation process is when you come from the field to the office and you start editing. This is the moment when there is a big risk of losing, modifying and confusing information. There is an interesting ICCROM experience that I would like to mention in this regard. At the beginning of the 1990s there was an ICCROM/ICR documentation project, coordinated by the architect Elisabetta Giorgi. For the stone façade of the Church of S. Andrea della Valle in Rome she made the experiment of just using the hand-drawn graphic records made by the conservators on site as the final version of the graphic documentation. The manual maps were scanned and the computer allowed to view them as overlays onto the same base map that was used for recording. A very simple way of avoiding loss of information. The diagrams did not look as fancy as other computer-edited records. They were manuscripts. As a fact, they also included some hand-written annotations made by the conservators on site.

PIQUÉ: We have similar methods. We record on transparencies so we can scan them as they are and they do not need to be copied. Copying takes so much time and can introduce errors. I would also like to comment on the glossary. It is really difficult to objectively describe a phenomenon. It is difficult because we try to describe what we see without relating the description to the possible cause. One example is 'damage caused by salts' which is an interpretation of what we see and not an objective description. It would be more correct to define it as 'disintegration of the plaster' or 'presence of white efflorescence.'

SCHMID: This is especially important when you want to show different intensities of the same phenomenon. It happened to us that we wanted to record different intensities of a black deposit on stone. The only way is to describe them and to add photographs. Maybe you define three categories but you could also select ten because the intensity increase is gradual.

BUZZANCA: I think that in the step-by-step scheme you showed one could add a column indicating who is responsible for the operation. It would be important to define the tasks of each actor in this process.

PIQUÉ: I am also working on a project to compare different ways of recording data in the field to obtain results in digital form. In that case we prepared a table where we indicate the expertise required in each step.

WONG: I would like to look at the data organization, the editing and the presentation stages. Where would you factor in the manipulation of data stage (looking specifically at graphic documentation) within this documentation structure? And, if you are converting information to digital form would the presentation stage also allow for the further manipulation of data in order to actively correlate and query information collected.

PIQUÉ: The transformation in digital form comes after we have collected all data manually. The presentation consists basically of choosing an adequate scale and combining recorded phenomena in a meaningful way.

GROTE: I think that graphic documentation only makes sense if you have a final discussion with all experts participating in the project. I am missing this final point in your matrix. We had different projects of research in which we have produced a big amount of graphic diagrams which also were stored but never discussed and analyzed with everybody. Only in this way can graphic recording be a working tool and not just documentation.

PIQUÉ: Presentation is not only for the public but also for the conservation team. It is there where the discussion comes in. This table is structured for the graphic recording process and not for all the other components of conservation documentation in the assessment phase (like scientific investigation, etc.)

ZEHNDER: What is striking to me is that you are always working with a local team, which has already done a preliminary condition assessment and is therefore aware of the general situation. So it seems that the problems are already defined and you provide support for the performance in detail, which I consider as a second step after the general assessment.

PIQUÉ: Projects start because a governmental institution asks the Getty Conservation Institute for technical help in managing and taking care of a particular cultural heritage. So certainly they have identified problems. The levels of preliminary assessment and understanding of problems vary enormously from one country to the other, depending on the stage of development and the preparedness in the field. Some are advanced and have a lot to teach us. We work together taking available data as a starting point.

Discussion following Haydee Orea Magaña's presentation:

CATHER: There were a couple of issues [presented] that are new to the discussion. One of them is the use of video, a wonderful tool but a nightmare for archiving. The other particularly interesting thing is that we all tend to consider that our approach is constrained by our resources, these resources being skills and funding. So I think the idea of emergency documentation needs to enter into our discussion.

CASCIU: In case funding and or time is limited you need a minimum degree of documentation independent from the possibilities.

PIQUÉ: To limit use of resources, it is essential to graphically record what is really necessary and that must be considered when we create the glossaries. We need also to consider and utilize other formats of documentation and in particular photography. Often people spend a lot of time trying to document graphically phenomena that can be better and faster documented by a photograph.

OREA MAGAÑA: If we are in an emergency we just document what we see. The later programme would be to understand why we saw what we saw and make research. We use video now and photographic cameras and we try to collect the maximum information. We also have the collaboration of art-historians, archaeologists and architects who go to libraries and try to do a very quick work putting together essential information in a 1-2- page report.

SCHMID: Certainly an earthquake is a very dramatic emergency. However, I think that due to limited funding and insufficient awareness, cultural heritage conservation is an emergency in general. I propose to consider the emergency situation in general for our discussion.

OREA MAGAÑA: Yes, if you go to Puebla near Mexico City, about 400 buildings were damaged by the earthquake and about 200 have collapsed. We have a lot of mural paintings there. What we do is to just record what we see. For the first time we have used digital cameras and laptops and we have designed a documentation form which provides information to everyone – also to people from outside the conservation field.

Discussion following Elke Behrens's presentation:

PALUMBO: A technical question. Have you already developed a GIS for this project or you are based mainly on AutoCAD with ACCESS as a database support?

BEHRENS: We started with AutoCAD MAP2000 and on the scaffolding we developed as a team the first steps for a database. These two programmes are compatible and there are no problems to create links to the database with AutoCAD or in another way.

SCHUDEL: I have an observation which is also relating to the former speaker. I think graphic documentation is at least to a certain extent visual information and has a meaning in itself. On some slide I saw red triangles, black dots and parallel lines. The red triangles jumped more to the eye than the other patterns. If you do not mean that the phenomenon expressed by the red triangles is more important then the others it should not be in that way. If the dots do not refer to an 'open,' not well delimited surface phenomenon one should not use dots. On the other hand, parallel lines should be used to visualize a phenomenon with a well-defined surface. The same for photographs. You had some photographs taken with the light coming from the right side. Usually, raking light photographs should be taken with light coming from the left upper side. Of course this is not always possible, but then you should indicate that. Because I could read other things than you who know that particular situation.

LEITNER: I agree that graphic signs or colours can be used to give a certain importance to something. And as a fact what one wants to emphasize in a particular case might be very different to another. This makes the use of standardized graphic signs, as in geography, so difficult in our field. For example you showed a diagram where well-preserved areas of the painting were shown in red and badly preserved areas in green. I would like to see that differently because there is also a psychological meaning of colours. I would appreciate a discussion on how to use graphics from a psychological point of view in order to best transport information. Everybody has different feelings about this but a basis could be the «Gestaltungspsychologie.» I used the standard legend developed by the NLD Hannover, which provides an excellent basis for mapping. However, the range of symbols and the colour palette are rather limited. So I used these standards just as a reference guide, adding and modifying symbols where I found it was necessary. Probably it will be important to have standard legends when you have an archival database. But for presentation one must have the liberty to use graphic signs that best express what you want to convey.

BEHRENS: I know this problem and we were trying to consider it, but it is very difficult because nobody accepts guidelines like geographical maps, where the colour blue is only for water or the colour green is a sign for trees. It would be the next step to create a thesaurus for wall-painting damage with one-colour palettes and their corresponding hatchings because you cannot show everything with our simple manual legend which consists only of about 12 colours. Still, one step forward would be to create a new graphical presentation system.

GROTE: May I add something as I am from the same department? There might be a misunderstanding with regard to mapping. To me mapping is not a real documentation tool. Mapping is depending on the interpretation by the conservator. The mapping done by the same conservators can be different in the morning and in the evening. For us mapping is a way of seeing a mural painting better; to learn seeing first and to interpret these observations for yourself and with the team. Mapping never shows the objective truth. It is just a working instrument, which provides the basis for discussion and interpretation. This is the essential step that must follow.

PALUMBO: With the spreading use of computers and layer structures, the matter of colours and symbols becomes almost irrelevant. Each single phenomenon is recorded on a separate layer and that is how it will be stored. When we want to output this information for presentation, then we have to worry about how to do that. In fact, at the GCI, we are recording the information just by delimiting the area with a line. We do not use hatching or anything. I was impressed by some diagrams shown by Mr. Pursche which were just outlined areas with a numeric reference code. That is probably the best way to do it.

Discussion following Adrian Heritage's presentation:

ZEHNDER: Could you explain what you mean by referencing the process instead of measuring it? You said it is more important to reference than to measure. I do not know exactly what you mean by that.

HERITAGE: References are measurements, but you have three measurements that give you one reference. What I wanted to get away from a bit is the feeling that we have to measure everything in order to have accuracy. I think we can't do that because there is too much information coming out.

ZEHNDER: So you mean it is important to know what you are going to measure in order to have significant information and not just data.

PIQUÉ: I think referencing is essential for future monitoring.

SCHMID: You also showed examples of thermography. As far as I know it is very difficult to interpret a thermographic image because of the many variables that can influence the fact of areas appearing dark or light coloured. By using this method, some people tried to map detached areas of plaster, which being warmer than the areas adhering to the wall can theoretically be identified. However, also the moisture content influences the result and might confuse it.

ZEHNDER: The crucial thing with such measurements is always the interpretation. The equipment alone is of no use. Every scientific investigation must start from a problem or a question to be clarified.

Discussion following Jacques Neguer's presentation:

ZEHNDER: In the example you showed I miss the link between very accurate observation, monitoring and reliable interpretation of what you measure. I am sorry but I don't get clear what really are the causes. For instance you show three stages of the condition and on the right hand you have the climatic evolution. I am afraid that you get a lot of data. But somehow it is not concise.

NEGUER: First of all I have the data on-line. Second, if something happened, I have the possibility to turn the map of the previous condition, to the weather and climatic data and to the diary of the intervention. In this very complex site everything is possible. In Cesarea you have salts everywhere and you know exactly the condition for their crystallization. We do not do scientific analysis of all this. We try to have the information of what happened and what will happen.

SCHMID: I agree that when you do photographic monitoring, you need to record the climatic condition under which the image was taken. There are so many variables depending on the environmental conditions. For example, salts might be visible only in certain periods of the year or hours of the day and dissolve completely when the climatic condition changes.

ZEHNDER: If we have understood the causes of damage we can reduce the measuring to the crucial parameters. For example, we know that salts crystallize when humidity is falling below a critical value, so I think we agree on that.

NEGUER: For me, for monitoring it is important to have a repetition of results or observations. Nothing more.

CATHER: I was interested in the repetition of the mosaic condition assessment, and you said that you have altered it by having more precise base maps and by using AutoCAD. Do you think that the mapping exercise is repeatable from one year to another when you may have different conservation staff? Do you think the results are genuinely comparable?

NEGUER: Yes, because the use of this type of mapping is more objective. It is also possible to calculate the mapped areas.

Discussion following Jun Zheng's presentation:

SCHMID: What became very clear in this presentation is true not only for China. Due to scarce financial resources for conservation, we always have to decide what priority we want to give to documentation and how much we want to spend for it. You said that conservation professionals in China often do not know what level of documentation is sufficient. Again, this is a question that is often asked all around the globe.

CATHER: You said that the situation regarding the awareness of the importance of documentation has improved already. How did that come about?

ZHENG: One aspect is the increased investment into cultural heritage. Only five years ago it was only one tenth [of what it is now]. Another aspect is that administrators now start to request documentation for proposals or final reports. There is also more competition between conservators now.

Discussion following Heinz Leitner's presentation:

PALUMBO: You are probably familiar with the American expression "garbage in - garbage out." A friend of mine who is an archaeologist but also uses computers a lot has a theory that the end of true archaeological thought coincided with the widespread availability of desktop computers. This means that archaeologists are working less on the interpretation and more on getting nice stuff out of their computers. This is a real problem. The only solution is that we really think of computers as tools for our jobs, that we get back to our role of thinkers and masters and stop pretending that computers will solve our lives.

LETELLIER: In the first part of your presentation you brought up the issue that you over-invested in computer technology. What advice would you give to people that want to invest but not over-invest in new technology?

LEITNER: It is important to get training before. It is more beneficial to invest in training than into hard or software.

CATHER: I wanted to address your suggestion about conservation-specific adaptation of software programmes. I see new software versions as one of the big problems. You always have to get the latest version, you have to upgrade. We are all in this vicious circle. I am not sure that as a profession we can justify specialist adaptations, especially in terms of keeping up new versions. Maybe one thing we could ask specialists is to provide templates and some guidance for non-specialists in a particular application. I think this is very feasible.

SCHMID: Computers should make our lives easier – from my experience, with regard to graphic documentation it was often the contrary. If we accept an increased time and cost investment we must really be sure that it provides us with a notable advantage. A cost-benefit analysis is necessary.

SCHUDEL: Computer is a communication tool. I do not believe that this tool gives you back what you put in. Any tool has a special predestination to give information. Every tool leaves its marks on the information. I should like to know what is the mark that the computer leaves on the information.

LEITNER: The computer concept is a mosaic system. You collect things and then you put them together. That is a big danger. You just use all the things you collected without selecting them critically. Due to the capacity of computers this is a big temptation.

Discussion following Rolf-Jürgen Grote's presentation:

PIQUÉ: You are addressing an enormous task: building up a database which will contain information about a large number of building sites with wall paintings. I was wondering about the resources that you are using, which expertise is involved, how many people? Another crucial aspect is the maintenance of this database. How do you ensure that the information will be available in the future?

GROTE: It is really a problem to have the continuation of this work in progress: Information always has to be updated. The only way of financing these activities is through projects or through the collaboration with students from the high school for documentation in Hannover. The first version of our database was quite simple and rather cheap, only about 7,000 US$. We worked very systematically not to lose the general view. With regard to your first question, we have small teams composed of an art-historian and a conservator. This is very important. Data collection is very time-consuming. There are about 250 wall painting objects of medieval times in Lower Saxony and we are now scanning the last sites after about ten years work. The problem now remains to keep the database updated by trained persons. At the moment we have one documentalist. But it remains a problem for the future.

CATHER: How do you tag the information? How do you make sure that it is obvious to the user where the information comes from? How is it identified in terms of source, its date and its reliability? With these electronic means it is so easy to edit, to alter, to add new information.

GROTE: As I showed you on the slide, we have a monitoring item. There you can read that this is the status of 1995 and another is of 1998. Then you can combine the two situations and check whether anything has changed.

Discussion following Giancarlo Buzzanca's presentation:

BEHRENS: I would have liked to have this bottom bar since years. How have you managed to have an agreement amongst all conservators on which symbols or patterns are used? In Germany it was impossible to find an agreement because every conservator pretended to use the best legend.

BUZZANCA: This work of standardization will be done by the NorMal Commission. The commission collected and evaluated different experiences, but there is no official out-put yet and the Commission is already since some time, not active. However in computerized graphic documentation we need patterns only when we print the information. For the computer there is an inside-outside line – we only have to define the area with an outline and a code. Each phenomenon is recorded on a different layer and in this way the code of the layer is the code of the same phenomenon. A pattern is only a visual aid – it is a non-sense in terms of heaviness of the file. In AutoCAD we can use the solid pattern; colour is less space consuming in AutoCAD.

PALUMBO: I agree with this approach in the sense that we do not need new software in conservation documentation. The flexibility of existing software allows us to make customizations. I have to confess that in the project in which you participated we did not continue with the customization because our conservators were trained in AutoCAD and they wanted to work directly with the AutoCAD interface.

BUZZANCA: This is my goal. The customization is only to learn to work with this kind of instrument. Growing with experience the conservator can build his own logical structure using in any case the software tools, such as layering and file naming, which are designed for the conservator. If we work in two dimensions one can use AutoCAD-light, which is more simple and cheaper. A low cost means a greater diffusion of digitized information.

SZAMBELAN: It is a very interesting problem with 2-D maps in approaching the three-dimensional environment for a GIS for example. We can have many mapped objects, which can refer to one phenomenon, to one place on the 3-D object surface. It is a big problem particularly for databases because we create many records for one object. There are so called multipolygons or polygons with enclaves, which can be useful in some software systems solving this problem.

LEITNER: I would have been happy for years to have such a customized system that gives you the different sections. A system where you choose 'techniques of execution,' 'preparatory drawing,' 'green line,' 'red line,' whatever – 'it's done by brush,' 'it's done with a pencil.' That is all a conservator needs. You went a very important way together with the conservators. With regard to standards you showed how it was developed for one object during the work and not beforehand. This might be a way to come to a more generally accepted standard.

Discussion following Rafal Szambelan's presentation:

ZEHNDER: Could you explain to illiterates in computer graphics why you use both CAD and GIS?

SZAMBELAN: GIS operates best on the earth's surface or in two-dimensional environment. It rather refers to flat objects. With CAD you can build three-dimensional objects and fill them with attributes. For example my watch ... you can build a model and assign attributes to it, such as: this part is made of plastic and has for example a special thermal coefficient. Both systems are used together if you want to show items or areas on a vault or curved surface. And maybe in the future you have a specific question such as: how does the humidity from the roof affect the wall surfaces? There are reasons why we should have a 3-D model.

PETRESCU: I would like to add a few remarks. CAD means computer-aided design and drafting. It is basically meant to solve drawing and design problems. To design a ship or a car, for example. GIS is concerned with geographic maps and information referring to the earth's surface. It is basically meant to solve any information-processing task related to geographically referred information. Now, about three dimensions. It is no secret that initially, the most important users of GIS technology were military organizations. One of the main needs of the military consists in processing 3-D information, such as digital terrain models. So what was said about three-dimensionality is not true. 3-D is crucial to GIS and it is implemented from the very beginning in its design. Of course this does not mean that every particular GIS software has 3-D functions but, generally speaking, 3-D data processing is something that cannot be separated from GIS technology.

SZAMBELAN: I agree with Mr. Petrescu. That might be a mistake. I wanted to make it more simple.

CATHER: I want to pay my compliments to Mr. Leitner and Mr. Szambelan because as a colleague I have been following this work for years. To see what they have accomplished in the private sector, with huge personal and financial cost, is really an achievement.

Discussion following Filippo Petrignani's presentation:

PALUMBO: I think that it is very important that there has been a porting or translation of the data into AutoCAD. Because otherwise the data would have been lost.

PETRIGNANI: In 1996, the *Direzione Generale* of the Vatican Museums carried out a DXF format translation of all data collected to obtain compatibility with the current release of AutoCAD. The amount of data that were translated was about two gigabytes.

PALUMBO: This is typical of systems created just for one project. We have to run away from these I believe; otherwise we are going to have these problems. But certainly at the time you could not do anything else.

PETRIGNANI: I agree with you, but in 1986 there was no choice.

Discussion following Stefano Casciu's presentation:

PALUMBO: You touched upon the matter of the virtual reintegration of lacunae. This was also adopted in a site in Switzerland with a very faded mural. Unfortunately I do not remember the name of the site. They did the virtual infill operation on a computer. Then they produced a slide of it, which they projected over the original painting – to its original scale. So you have a virtual restoration which is almost as visually effective as a real intervention, and without touching the original. I think this is quite a good idea.

CASCIU: Piero della Francesca also used a lot of secco painting in his technique. This is the reason why many parts, like the hats and some garments, are completely lost. On the basis of some evidence, such as small traces of colour within the micro-cracks it would be possible to reconstruct some of the lost parts with a rather high certainty. This would be fascinating to do but for evident methodological and philological reasons it can certainly not be done on the paintings themselves. This is where the information technology can give an enormous contribution. Making these integrations on video one can reconstruct the original chromatic effect in areas of the painting where the intervention must necessarily be limited to conservation operations.

BUZZANCA: In one slide of your presentation I saw a box with some textual information on the right side. Is this text only a comment in the slide or is it an indexed and linked information included in the database?

CASCIU: All texts in this archive have a possibility for queries and indexing. This is the text that the conservator wrote in that day. However, it is not copied exactly, but slightly revised, especially with regard to terminology.

Extract of discussion during the plenary session following the first meeting of working groups

SCHMID: I wanted to remind everybody that the Framework Document we are trying to put together should specify the minimum requirements, the minimum acceptable practice, for producing a correct graphic documentation of mural paintings. This is an important requirement. In WG1 people were discussing whether they should think of an ideal case. On the contrary, we should think of a situation with limited resources, in which however, one has to produce something correct, that satisfies the needs of the project. You should then also specify supplementary options to that minimum, which can be proposed if enough money is available or if one thinks it is necessary to apply them. This is the task for the working groups, as we defined it in our Planning Meeting in February.

ZEHNDER: Just an additional question. Should there also be a definition of the maximum requirement?

HERITAGE: What we decided in order not to lose categories of information is that we would define the essential categories as the minimum requirement and that everything else would go into a desirable category, but that is obviously a grey area.

CATHER: I am having a problem with this, because the minimum for what? I don't think a minimum can be defined. The minimum for one thing might be completely different from the minimum for a different function.

PIQUÉ: I agree that it is going to be really difficult and might not be possible. I agree that each project might have a kind of information that might be insignificant to another and therefore it is difficult to define a minimum requirement. But I think we can start working on it.

SCHMID: Maybe a way of identifying minimum requirements would be to carry out a systematic analysis of the usefulness of the documentation carried out in conjunction with previous interventions. It is now more and more common to find thorough documentation of interventions that were done 20-25 years ago. If we examine these paintings again today it will be easy and highly instructive to see what is really of use to us and what is missing. Maybe we will find that photographs of a certain type are especially useful, or discover that the graphic documentation is too general or too detailed and extensive. A systematic study of this type might help to distinguish the necessary from the superfluous.

LETELLIER My experience as the responsible officer for recording/documentation within Parks Canada is that we had to satisfy five regional offices in which we had about 100 conservation experts dealing with different projects. In the beginning we tried to do a complete documentation for each project they where working on, but some criticized and said "you are doing too much recording for us" or others would say, "there is a lack of information (or recording) for us to work from." So we developed a 'Request for Recording Form' – a very simple form, which gives many recording options (i.e. from a site plan, to sections and elevations of buildings, and photographs of details, and so on). First we had to educate the clients as to what the options were and how they could use the form to better define their recording needs. Every project was somewhat different and we had to discuss specific needs with each client individually. As a result, these discussions led to precisely defining the conservator's recording requirements which translated into days of recording work (and related costs). Moreover, this document became a contract. From the day we introduced this 'request-for-recording form,' our clients were smiling, because they were able to precisely tell us what they wanted. Client A was totally different from client B and C in his requirements. So my answer is: there are no pre-defined minimum or maximum recording standards ... the scope of recording depends on project needs and funds available!

PETRESCU: I suggest that we say 'basic requirements' instead of 'minimum.'

CATHER: I just can't see how we can proceed on this basis. If you are doing conservation of a wall painting you might have investigations of salt efflorescence or bio-deterioration, that is of the state of conservation at a scale which is of interest to relate to probable environmental deterioration as opposed to mechanical damage. I think we have to define the function of documentation before we can say what we need to know.

26
INTRODUCTION TO THE SELECTED BIBLIOGRAPHY ON COMPUTER-AIDED DOCUMENTATION

For reasons of space, the bibliography itself has been put on the CD-ROM that accompanies this volume.
The objective of the bibliography was to collect the titles of books, articles and other text references on methods and means of graphic documentation, with a special focus on computer-aided applications. These references are often difficult to locate, partly because they are sometimes included in publications on other topics.
This draft version is at present a work in progress. It is a working document useful for distributing and sharing knowledge.
After the GraDoc seminar, additional references from the papers were included. We apologize for any inadvertent omissions.
For some texts, indications are given on the shelf location in the libraries that were consulted during the research (ICR, ICCROM, Getty Center). Moreover, an indication is provided when the text is available on the Internet. Actually, some texts are exclusively published through this medium.

27

QUESTIONNAIRE SUMMARY

Lorinda WONG

Condition Recording in the Field of Wall Painting Conservation, 1997

Questionnaire Summary

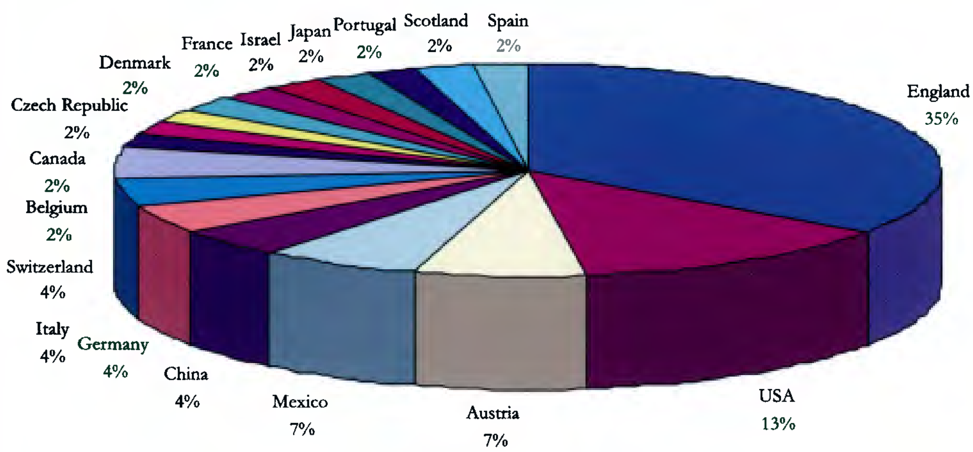
Introduction
Definitions
Results

Questionnaire Summary

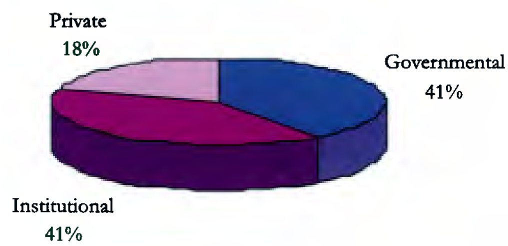
Introduction

The existing questionnaire, carried out in 1997, focused specifically on the methods and means of condition recording in the field of wall painting conservation.[1] Out of the 122 questionnaires sent, there were 46 respondents from 18 countries with a distribution of responses from those working privately, and in governmental and institutional roles.[2]

Questionnaire Results: Percentage of Respondents by Country



Questionnaire Results: Respondents by Working Situation



[1] Lorinda Wong, "Condition Recording in the Field of Wall Painting Conservation," unpublished post-graduate diploma dissertation, Courtauld Institute of Arts, Wall Painting Department, London, 1997.
[2] Drawbacks of the questionnaire included that it was heavily focused on England (35%) and within Europe (66%). In addition, only 18% of the respondents were working privately in comparison to 82% evenly distributed between governmental and institutional roles.

Questionnaire Summary

Definitions

▪*Condition Recording*: the collecting and setting down for preservation information on the particular state of being or situation of an object with respect to its circumstances at a given time

The questionnaire focused on condition recording which is only one component of conservation documentation as a whole. However, the recording of condition encompasses not only the physical observation of a painting and its surroundings but must also take into account any *relevant information* which enhances ones observation of condition phenomena as well as aids in the subsequent interpretation (ability to recognise, identify and define) of this information. Therefore, the recording of condition could also include aspects regarding structural support, techniques of execution, historical alterations, previous interventions, etc.

For condition recording in particular the physical recording of such information includes not only *written* and *image-based* formats but also primarily *graphic documentation.*

▪*Graphic documentation*: a record of phenomena or other topographical data created by superimposing symbols, patterns and/or colours over a base map

Therefore, as graphic documentation plays such a prominent role in the recording of condition, a large portion of the results from this questionnaire have been found relevant to the GraDoc seminar. However, it is important to keep in mind that the questionnaire results do not focus exclusively on graphic documentation but also takes into account other methods and formats of recording condition. Likewise, it should be noted that graphic documentation has applications other than just for condition recording.

For the questionnaire, three levels of condition records were specified including the *A. Preliminary Condition Assessment*, *B. General Condition Survey* and *C. Detailed Condition Report*. The graphs following each question posed show results of all three levels of condition recording. However, the majority of information extracted for the GraDoc seminar has been taken from data provided for the *B. General Condition Survey,* which appeared to be the most representative of the results. The number in parenthesis following the results of each question represent the total number of responses.

Questionnaire Summary

Results

I. GENERAL QUESTIONS ON CONDITION RECORDING:

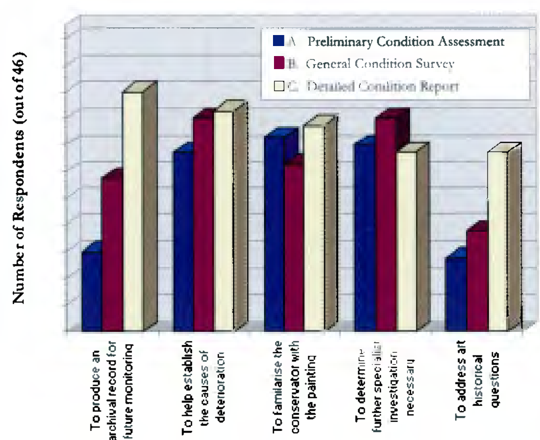
Question 1:

The recording of condition can be investigation-related. What are the objectives?

Results:

- *To determine whether further investigation is necessary (32)*
- *To help establish the causes of deterioration (31)*
- *To familiarise the conservator with the painting (25)*
- *To produce an archival record for future monitoring (24)*
- *To address art historical questions (17)*

Questionnaire Results: Investigation-Related Objectives of Condition Recording



Comments: The results are not specific with regard to graphic documentation which is only one of the *methods* used for recording condition. For example, *To determine whether further investigation is necessary* and *To establish the causes of deterioration,* listed as the two most important objectives, can be achieved by a variety of recording methods of which graphic recording though playing a key function is only one example.

However, most of the factors mentioned are typical objectives for carrying out graphic documentation in general. For example, graphic documentation is definitely used by conservators as well as other related professionals as a way *to familiarise themselves with the painting*.

Questionnaire Summary

Results

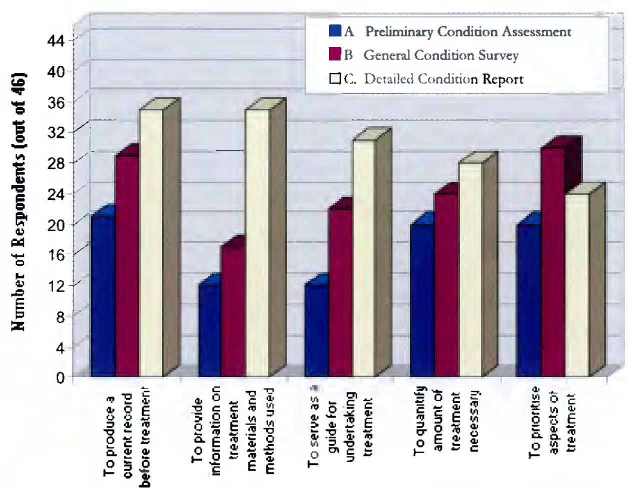
Question 2:

The recording of condition can be treatment-related. What are the objectives?

Results:

- *To prioritise aspects of treatment (30)*
- *To produce a current record before treatment (29)*
- *To quantify amount of treatment necessary (22)*
- *To serve as a guide for undertaking treatment (21)*
- *To provide information on treatment materials and methods used and location (18)*

Questionnaire Results: Treatment-related Objectives of Condition Recording



Questionnaire Summary

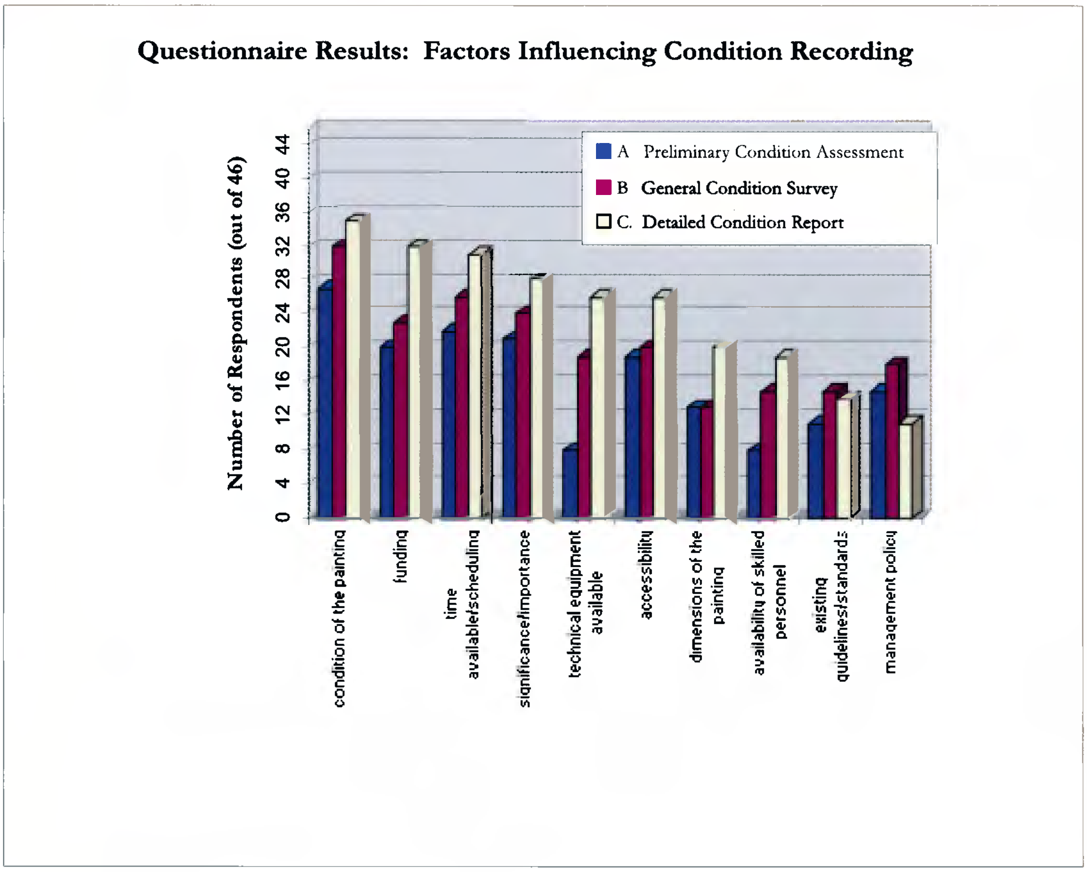
Results

Question 3:

Which of the following factors may influence the level of recording?

Results:

- *Condition of the painting (31)*
- *Time available / scheduling (26)*
- *Funding (25)*
- *Significance / importance of the painting (23)*
- *Technical equipment available (17)*
- *Management policy (17)*
- *Dimensions of the painting (17)*
- *Accessibility to the painting (16)*
- *Existing guidelines / standards (14)*
- *Availability of skilled personnel (13)*



Questionnaire Summary

Results

Question 4:

The condition of paintings may be recorded with different levels of detail and scope.

Results :

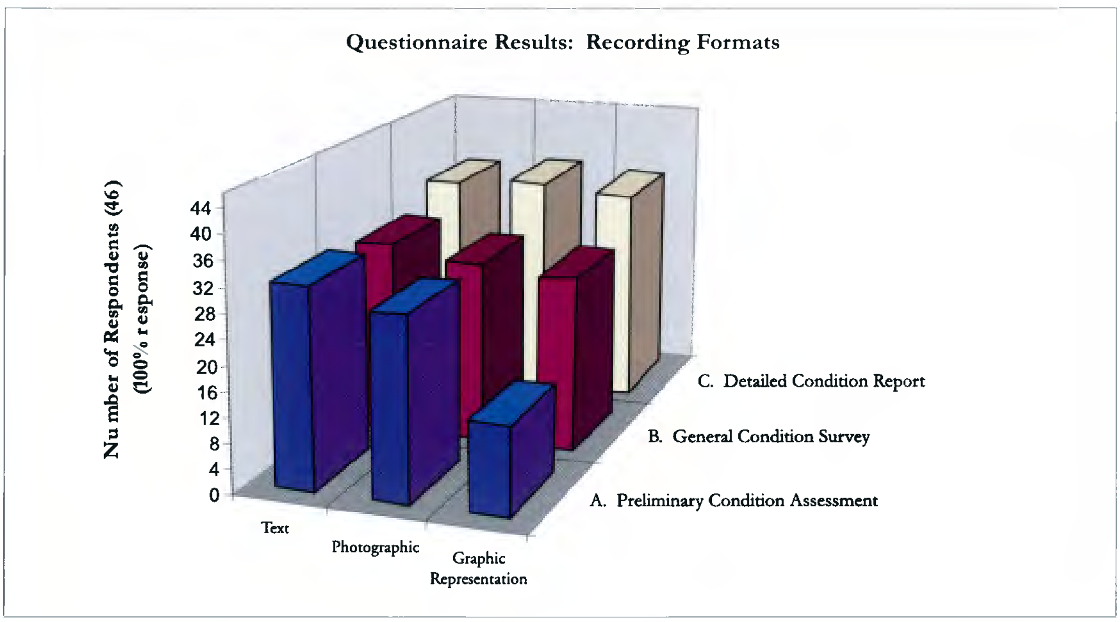
- *the level of recording is standardised (11)*
- *the level of recording is determined for each painting (29)*

Question 5:

Which of the following do you normally use to characterise condition?

Results:

- *Text (37)*
- *Photographs (36)*
- *Graphic representation (31)*
- *Other*



Comments: The use of text, photographic and graphic representation as recording formats for condition recording seem to be fairly equally weighted with text (80%), and photographs (71%) being slightly more used than graphic representation (67%).

Questionnaire Summary

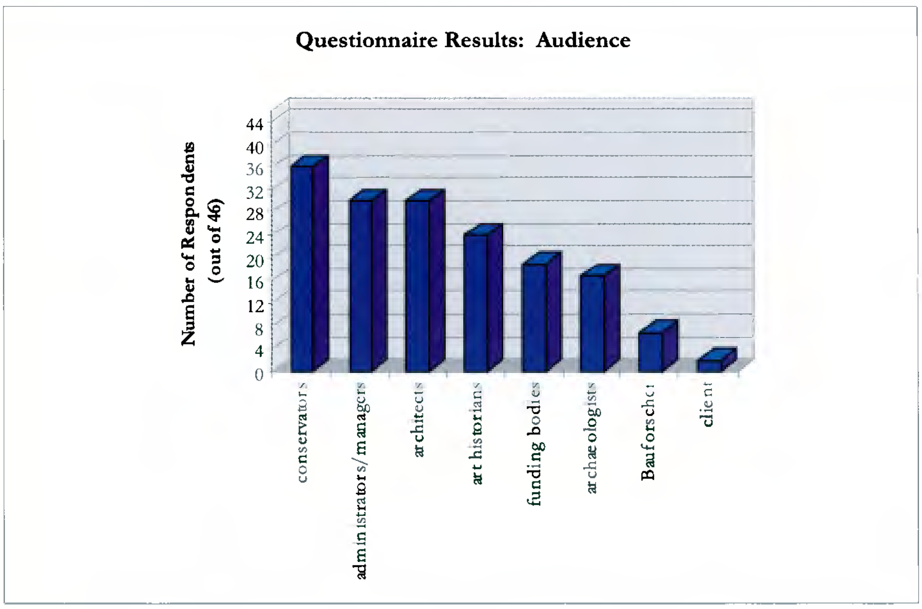
Results

Question 6:

Who uses this documentation?

Results:

- *Conservators (35)*
- *Administrators / managers (29)*
- *Architects (29)*
- *Art historians (23)*
- *Funding bodies (20)*
- *Archaeologists (15)*
- *Bauforscher (15)*
- *Client (6)*[1]
- *Scientists (1)*[2]



[1] The small percentage of respondents working privately as opposed to those working within governmental and institutional roles may explain the low results for "clients". However, it may also indicate that graphic documentation is of less interest to those not working directly within the field

[2] "Scientists" was not initially listed in the questionnaire but was later added by a respondent. This may explain the low number of responses.

Questionnaire Summary

Results

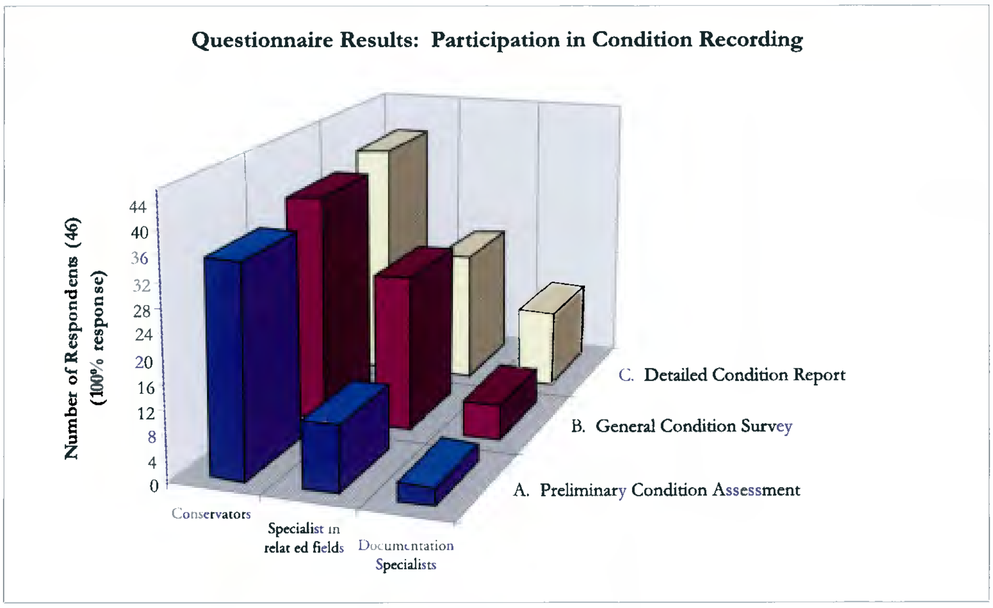
Question 7:
Who participates in recording wall painting condition on site?

Results:

- *Wall painting conservator (38)*
- *Documentation specialist (5)*

Specialists in related fields:

- *Architects (13)*
- *Scientists (6)*
- *Archaeologists (5)*
- *Photographers (5)*
- *Art Historian (2)*
- *Draughtsperson (2)*
- *Specialist Conservator (2)*
- *Structural Engineer (2)*
- *Technician (2)*



Comments: The actual number of people participating in the recording process appears dependent on the size of the project and allocation of funding for documentation. Questionnaire comments specify the benefit of fewer participants as it is, 'difficult to have uniform results', 'interpretation of phenomena is very subjective' and 'too much variation likely to be introduced if more than one person participates'. However, a few respondents also mentioned the benefit of more people participating to allow for discussion and consultation. While others suggested that the entire team participates in the observation but only one person carries out the actual recording.

Questionnaire Summary

Results

Question 8:

How do you ensure clarity and consistency in the data recorded?

Results:

- *use standard terminology with definitions of decay phenomena (23)*
- *include explanatory notes (20)*
- *include a type of 'visual glossary' with photographs or illustrations of decay phenomena (18)*
- *include a narrative description of each phenomenon recorded (14)*

Question 9:

Who is responsible for producing the finalised documentation?

Results:

- *Conservator (37)*
- *Documentation specialist (5)*
- *Other*

Comments : Results indicate that conservators are mainly taking part in the whole process of graphic documentation with related specialists and documentation specialists (though still quite low in number) slowly growing in number due to the increasing amount and advanced technical level of graphic documentation currently being undertaken. Comments suggest that the number of people participatingin the production of finalised documentation varies, but can include a wide range of people such as site managers, technicians, documentation specialists, data entry persons, team leaders and project co-ordinators. It was suggested by some that there is a need for a co-ordinator to oversee the whole process.

Question 10:

Do you use a verification system to check the accuracy of condition recording?

Results :

- *no (22)*
- *yes (8)*

Questionnaire Summary

Results

Question 11:

What happens to completed documentation?

Results:

a. Physical records:

- *additional copies are produced (33)*

Results:

b. Electronic records:

- *hard copies are produced (17)*
- *electronic copies are produced (on disk, optical disc, etc.) (16)*

Question 12:

How are these records accessed?

Results:

- *all records are organised and stored in an archive (30)*
- *copies made as required (24)*
- *information is stored on a database (10)*

Questionnaire Summary

Results

Question 13:

What methods are used to ensure the preservation of documentation

Results:

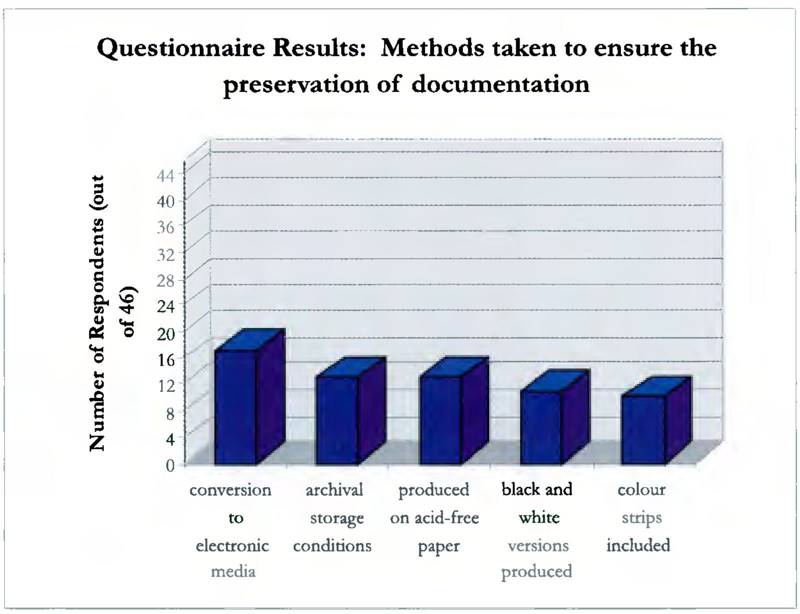
a. Physical records?

- *Conversion to electronic media (15)*
- *Archival storage conditions (14)*
- *Records produced on acid-free paper (12)*
- *Black and white versions of all photographs are produced (11)*
- *Colour strips are included to monitor the changes in colour photographs (10)*
- *Other*

Results:

b. Electronic records?

- *continual upgrading of electronicdata to match current software and hardware systems (11)*
- *maintenance of software to run old/obsolete programs. (10)*



Comments: No actual specifications were given for what was considered to be "archival storage conditions". However, results still indicated that only a small number of respondents are taking measures to ensure the preservation of documentation. Perhaps most interesting, the low number of respondents producing black and white versions of photographs.

Questionnaire Summary

Results

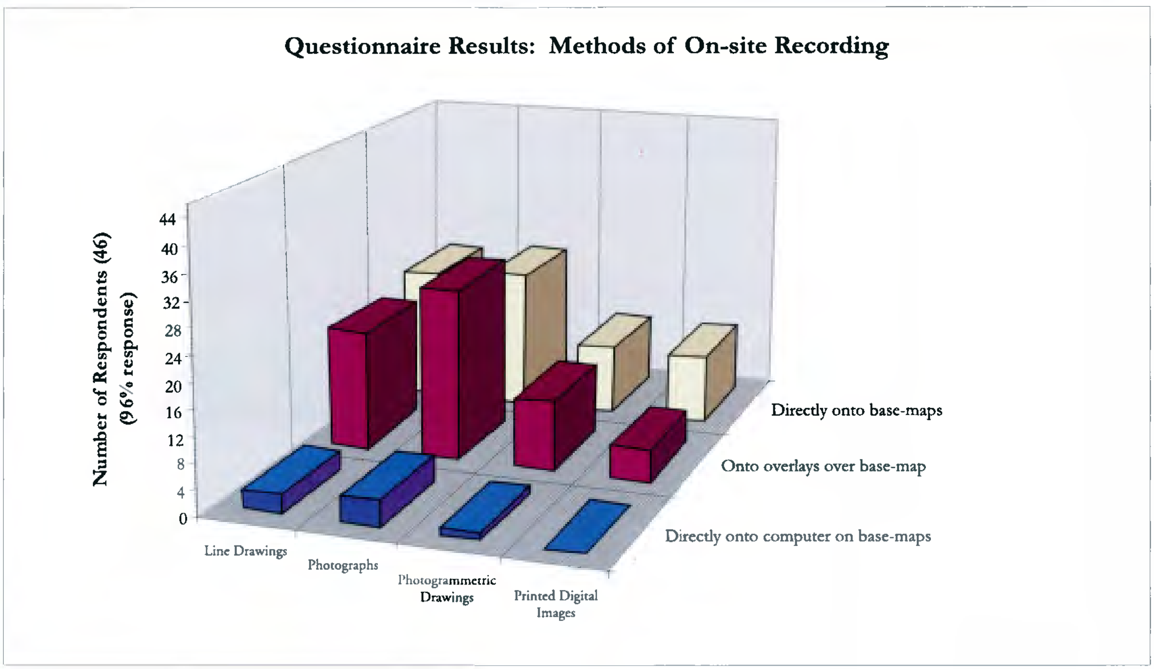
II. Questions Specific to Graphic Documentation

Question 1:

Which of the following graphic mapping methods do you use?

Results:

- *overlays on photographs (27)*
- *direct on photographs (25)*
- *direct on line drawings (24)*
- *overlay on line drawings (19)*
- *direct on photogrammetric drawings (12)*
- *overlays on photogrammetric drawings (11)*
- *direct on digital images (9)*
- *overlays on digital images (6)*
- *directly into computer on line drawings (4)*
- *directly into computer on photographs (3)*
- *directly into computer on digital images (1)*
- *directly into computer on photogrammetric drawings (0)*



Questionnaire Summary

Results

Question 2:

Which of the following methods do you use when you are recording condition graphically?

Results:

- *colours and symbols (21)*
- *black and white only (19)*
- *colour only (13)*
- *symbols only (12)*

Question 3:

Do you design your documentation so that it can be converted to black and white for reproduction?

Results :

- *yes (23)*
- *no (17)*

Question 4:

How do you determine the condition categories (phenomena) to be recorded?

Results:

- *Adjust condition categories to suit each individual painting (27)*
- *Use a standard list of condition categories specific for wall painting (10)*
- *Use a standard list of condition categories also applied to other heritage items (8)*

Questionnaire Summary

Results

Question 5:

What are you recording?

Results :

- *the manifestations of decay (e.g. flaking paint) (35)*
- *the general state of conservation (e.g. stable) (34)*
- *causes of decay (e.g. rising damp) (30)*
- *added materials (e.g. repairs) (27)*
- *aspects of original technique and materials (e.g. giornate) (25)*

Comments: This would also normally include non-condition recording layers such as sampling and treatment.

Question 6:

What related research is conducted?

Results :

- *conservation history (36)*
- *assessment of the building condition relevant to the painting (30)*
- *investigation of the principle causes of decay(29)*
- *general history (27)*
- *art historical (27)*
- *analysis of the painting (19)*

Questionnaire Summary

Results

Question 7:

How do you represent the varying levels of intensity within each deterioration phenomenon (e.g. slight to serious paint flaking)?

Results:

- *text description (34)*
- *photographs (32)*
- *graphically using different symbols (19)*
- *graphically using gradations of colours (or different colours) (14)*

Comments: Use of "varying density of symbols" was not listed as an option but was perhaps considered by some respondents under "graphically using different symbols".

Question 8:

How do you record superimposed (overlapping) phenomena?

Results:

- *Text description (29)*
- *Graphically on a computer using transparent layers graphically (25)*
- *Utilising a (traditional) system of overlays (24)*

Question 9:

How do you record the condition of curved surfaces (e.g. vaults)?

Results:

- *Photographs (34)*
- *Graphically flatten (distorting the image) (22)*
- *Rectified Photographs (12)*
- *Three-dimensionally on computer (6)*

28

GLOSSARY OF TERMS USED FOR GRADOC

This terminology was prepared in order to facilitate communication amongst the experts involved in GraDoc. The document includes a selection of what we considered to be the most arbitrary terms.
It is important to stress that this terminology is merely a working document and does not pretend to be anything more than this.

The document is divided into three parts:
Part 1. Terms relating to conservation documentation in general
Part 2. Terms relating to graphic documentation of mural paintings
Part 3. Terms relating to computer technology applied to documentation note: this part was especially made for those who are less familiar with the subject – for this purpose some of the definitions are simplified

The following references were used:
NOD - The New Oxford Dictionary of English, Clarendon Press, Oxford, 1998
GAHI – H. Besser, J. Trant, *Introduction to Imaging*, Getty Art History Information Program, Los Angeles, 1995
WEB - Internet.com - Webopedia: the only online dictionary and search engine you need for computer and Internet technology, www.Webopedia.com
note: often only extracts of the definitions provided by this source are given

Other abbreviations used:
GraDoc – definitions proposed by the GraDoc team
(Defined terms which are included in other definitions are given in *italics*)

PART 1 - Terms Relating To Conservation Documentation In General

Terms	*Definition*
Assessment	• The action of evaluating the nature of something (ref. NOD) **Comment**: assessment of the condition of a mural painting means to correlate/ interpret relevant data collected and to formulate results
Consistency	• The achievement of a level of performance which is not dependent on individuals and which does not vary greatly in quality over time (ref.GraDoc/NOD)

Condition Recording • To collect and set down for preservation information on the particular state of being or situation of an object with respect to its circumstances at a given time (ref. GraDoc)
Comment: condition recording is part of the *conservation documentation* done prior to the treatment

Conservation Documentation • The systematic collection, structuring and creation of access to data and documents from preliminary investigation, treatment, monitoring and quality control (ref. GraDoc)
Comment: see also *Documentation*

Data (also *information*) • General term for any type of information you are recording (ref. GraDoc)

Data Collection • Any compiling of information regarding an object (ref. GraDoc)

Documentation • Information acquired over time which constitutes a knowledge base (ref. GraDoc)

Format • A defined structure for the collecting and presentation of data (ref. GraDoc)
Comment: documentation formats are mainly written material, *images* and graphic records

Graphic documentation • The product of recording phenomena or other data created by super-imposing symbols, patterns or colours over a *base map* (ref. GraDoc)

Information Management • The process of acquiring, storing and sharing documentation to ensure its reliability, security and accessibility (ref. GraDoc)

In-situ examination • Examination carried out directly on the painting, its support and/or environment (ref. GraDoc)
Comment: includes mainly visual examination (under different light conditions), special photographic techniques, direct analysis and monitoring with portable instruments.

Image • A representation or reproduction of an object (ref. GraDoc)
Comment: can be a photograph or a *line drawing*

Levels of Recording • Extent and level of detail of *documentation*; dependent on given circumstances: e.g. nature of the object, whether it is an individual object or collection, whether conservation work is necessary (ref. GraDoc)

Presentation • The manner or style in which *documentation* or parts of it are given or displayed (ref. GraDoc)

Presentation tools • General term for any tool used to assist in the presentation of data (ref. GraDoc)

Recording • The capture of information at known points of time (ref. GraDoc)
Comment: note the distinction made with *Documentation*

Standard • A mutually agreed-upon designation that helps to ensure a consistent and understandable result (ref. NOD)

Survey • A general view, examination, investigation or description of something (ref. NOD)
Comment: in CONSERVATION DOCUMENTATION the term is often used as a synonym for Investigation, Recording. The term Architectural Survey implies the notion of investigating into structural conditions through the study of fissures and measured drawings.

PART 2 – Terms Relating to Graphic Documentation of Mural Paintings

Accuracy

- The degree to which the results of measurement, calculation and recording conforms to the actual value and object (ref. NOD)

Comment: in *graphic documentation* accuracy is relating to the topographic quality of the *base map*, the scale used and the precision and method used for locationg the phenomena.

Base map

- *Image* representing the painting upon which data can be graphically recorded or superimposed (ref. GraDoc)

Comment: usually a *Line-drawing* or a photograph

Category (also *Theme group*)

- A class or division of things regarded as having particular shared characteristics (ref. NOD)

Comment: in CONSERVATION DOCUMENTATION typical categories include Techniques of Execution, Condition, Previous Interventions, etc.

Direct recording

- The recording of information directly onto the final *base map* intended for presentation (ref. GraDoc)

Comment: see also *indirect recording*

Glossary

- An alphabetical list of terms or words found in or relating to a specific subject including explanations. A brief dictionary (ref. NOD)

Comment: see also *Legend, Thesaurus, Visual glossary*

Graphic recording

- The action of producing *graphic documentation* in situ (ref. GraDoc)

Comment: see also *Mapping*

Indirect recording

- A two-step process; *data* are first recorded onto a *base map* as a draft and then transferred to a final presentable form (ref. GraDoc)

Comment: see also *Direct recording*

Legend (also *Key*)

- Descriptive (text and/or *image*-based) information essential for the correct understanding of *graphic documentation.* Explains graphic symbols or colours, scale, etc. (ref. GraDoc)
- In presentation graphics, text that describes the meaning of colours and patterns used in the chart (ref. WEB)

Comment: see also *Glossary, Thesaurus, Visual glossary*

Line drawing

- Drawing delineating painting subject matter, extent of painting and architectural context (ref. GraDoc)

Mapping

- To record or document information topographically on a *base map* (ref. GraDoc)

Comment: see also *Graphic recording*

Measured Drawing

- Drawing produced by using actual measurements (ref. GraDoc)

Comment: can be done manually or by using technological aids (e.g. rectified photographs, photogrammetry, special computer software) and is normally done to scale

Overlays

- A set of physical transparent layers (e.g. acetate), superimposed on a *base map, on* which to record phenomena and other topographical data singly or grouped (ref. GraDoc)

Comment: see also *Layers*

Recording tools

- General name for any tool used to assist in the recording of data (ref. GraDoc)

Rectified

- Perpendicular to the plane of the subject (ref. GraDoc)

Comment: rectified photographs or drawings are usually also measured and/or scaled. See also *Digital rectification*

Scale • A ratio of the size of an *image* on documentation to the actual physical size of the subject (ref. GraDoc)

Symbols and patterns • Black-and-white graphic signs representing information to be superimposed on a *base map* (ref. GraDoc)
Comment: patterns are repeated decorative designs (ref. NOD); symbols are individual signs

Thesaurus • A book that lists words in groups of synonyms and related concepts (ref. NOD)
Comment: see also *Legend, Glossary, Visual glossary*

Topographic reference grid • Grid applied over an object (or the representation of an object) so that it can be divided into sub-groups and then into single units. Allows an object to be divided into identifiable parts to aid in location of features (ref. GraDoc)

Topographically correct • *Rectified*, without distortion and scaled (ref. GraDoc)

Verification system • Means with which to check the accuracy of *Graphic documentation* (ref. GraDoc)

Visual Glossary • A *Glossary* with *image*s illustrating features that may also be graphically recorded. Aids in the data collection process and eventually facilitates the understanding / interpretation by the user (ref. GraDoc)
Comment: see also *Legend, Glossary, Thesaurus*

PART 3 - Terms Relating to Computer Technology Applied to Documentation

Analogue image • A physical (non-*digitized*) *image*: e.g. a photographic print or drawing (ref. GraDoc)

ASCII • Short for American Standard Code for Information Interchange (ref. WEB)

Attribute • (1) A characteristic. In a word-processing application, an underlined word would be said to have the underline attribute. In database systems, a field can have various attributes. For example, if it contains numeric data, it has the numeric attribute.
• (2) In database management systems, the term attribute is sometimes used as a synonym for field.
• (3) In DOS systems, every file has a file attribute that indicates several properties of the file. For example, they indicate whether the file is read-only, whether it needs to be backed up, and whether it is visible or hidden (ref. WEB)

Bit-mapped image • See: *raster image*

BMP • The standard bit-mapped graphics format used in the Windows environment; by convention, graphics files in the BMP format end with a.BMP extension (ref. WEB)

Browser • Short for Web browser, a software application used to locate and display Web pages. The two most popular browsers are Netscape Navigator and Microsoft Internet Explorer (ref. WEB)

CAD • Acronym for Computer-Aided Design.
A CAD system is a combination of hardware and software that allows one to design everything from furniture to airplanes. CAD systems allow one to view a

design from any angle with the push of a button and to zoom in or out for close-ups and long-distance views. In addition, the computer keeps track of design dependencies so that when one value is changed, all other values that depend on it are automatically changed accordingly (ref. WEB)
Comment: sometimes given as CADD to indicate both design and drafting

Computer-aided recording (also *electronic or digital recording*) • Any electronic or digitally aided method of recording as opposed to *Conventional methods of recording* (ref. GraDoc)

Conventional Recording (also *traditional or manual recording*) • Any non-*computer-aided method of recording* (ref. GraDoc)

Customization • The modification of something to suit a particular individual or task (ref. NOD)

Data • (1) Distinct pieces of information, usually formatted in a special way. All software is divided into two general categories: data and programs. Programs are collections of instructions for manipulating data. Data can exist in a variety of forms – as numbers or text on pieces of paper, as bits and bytes stored in electronic memory, or as facts stored in a person's mind. Strictly speaking, data is the plural of datum, a single piece of information; in practice, however, people use data as both the singular and plural form of the word (ref. WEB)
• (2) The term data is often used to distinguish binary machine-readable information from textual human-readable information. For example, some applications make a distinction between data files (files that contain binary data) and text files (files that contain *ASCII* data) (ref. WEB)
• (3) In database management systems, data files are the files that store the database information, whereas other files, such as index files and data dictionaries, store administrative information, known as *metadata* (ref. WEB)

Database • System of sorting and organizing information around core categories of essential information, common to a broad variety of objects in order to facilitate its subsequent use (ref. GraDoc)
• A structured set of data held in a computer, especially one that is accessible in various ways (ref. NOD)
Comment: see also *Relational Database, Distributed Database*

Databank • A large repository of data on a particular topic, sometimes formed from more than one database, and accessibly by many users (ref. NOD)

Dedicated • Reserved for a specific use. In communications, a dedicated channel is a line reserved exclusively for one type of communication. The opposite of dedicated is general purpose (ref. WEB)

Digital imaging or Computer imaging • A field of computer science covering digital images - images that can be stored on a computer, particularly *bit-mapped images*. Computer imaging is a wide field that includes digital photography, scanning, and composition and manipulation of *bit-mapped graphics* (ref. WEB)

Digital rectification • A digital process by which a digital image is corrected to generate another *image* with correct proportions (ref. GraDoc)

Digitizing • To convert an *image* into an electronic format; this is done by (1) scanning an *Analogue image*, by (2) capturing the *image* directly with a digital camera (a *raster file* is obtained) or (3) by using a digitizer table (a *vector file* is obtained) (ref. GraDoc)

Distributed database • A *database* that consists of two or more data files located at different sites on a computer network. Because the database is distributed, different users can access it without interfering with one another. However, the DBMS (Distributed Database Management System) must periodically synchronize the scattered databases to make sure that they all have consistent *data* (ref. WEB)

GIS • Short for Geographic Information System. GISs are tools used to gather, transform, manipulate, analyze, and produce information related to the surface of the earth. This data may exist as maps, 3-D virtual models, tables, and/or lists (ref. WEB)

Hardcopy • Physical copy of an electronic document (ref. GraDoc)

HTML • Short for Hypertext Markup Language. An encoding format for identifying and linking electronic documents used to deliver information on the World Wide Web (ref. GAHI)

Interactive Links • Digital connections amongst related areas of investigation, typical for databases (ref. GraDoc)

Interface • (n) Something that connects two separate entities. For example, a user interface is the part of a program that connects the computer with a human operator (user). There are also interfaces to connect programs, to connect devices, and to connect programs to devices. An interface can be a program or a device, such as an electrical connector (ref. WEB)
• (v) To communicate. For example, two devices that can transmit data between each other are said to interface with each other. This use of the term is scorned by language purists because interface has historically been used as a noun (ref. WEB)

IT • Short for Information Technology, and pronounced as separate letters (ref. WEB)

Layers • Virtual *overlays* used in computer-aided graphic documentation where to each single information or groups of information can be assigned (ref. GraDoc)
Comment: see also *Overlays*

Metadata • Data about data; metadata describes how and when and by whom a particular set of data was collected, and how the data is formatted; metadata is essential for understanding information stored in data warehouses (ref. WEB)

Mirror site • A Web site that is a replica of an already existing site, used to reduce network traffic (hits on a server) or improve the availability of the original site. Mirror sites are useful when the original site generates too much traffic for a single server to support. Mirror sites also increase the speed with which files or Web sites can be accessed. Users can download files more quickly from a server that is geographically closer to them (ref. WEB)
• Server mirroring means to utilize a backup server that duplicates all the processes and transactions of the primary server. If, for any reason, the primary server fails, the backup server can immediately take its place without any down-time (ref. WEB)

Mosaicking • To create an *image* composed of several different *images* by piecing them together; usually the 'mosaic' is composed of overlapping detail photographs taken under standard conditions (ref. GraDoc)
Comment: can be done manually or facilitated by using specific computer software

Multimedia • The use of computers to present text, graphics, video, animation, and sound in an integrated way. Because of the storage demands of multimedia applications, the most effective media are CD-ROMs (ref. WEB)

Pixel	• The picture elements (dots) that make up a digital *image*, similar to grains in a photograph or dots in a half-tone; each pixel can represent a number of different shades or colours depending upon how much storage space is allocated for it (ref. GAHI)
Raster file or raster image (also *bit-mapped image)*	• An *image* composed of a series of *Pixels* (ref. GraDoc) **Comment:** single pixels have no spatial definition; they are characterized by one number (colour number); see also *Vectorized file*
Relational Database RDBMS	• RBMS is short for relational database management system and pronounced as separate letters, a type of database management system (DBMS) that stores data in the form of related tables. Relational databases are powerful because they require few assumptions about how data is related or how it will be extracted from the database. As a result, the same database can be viewed in many different ways. An important feature of relational systems is that a single database can be spread across several tables. This differs from flat-file databases, in which each database is self-contained in a single table. Almost all full-scale database systems are RDBMS's. Small database systems, however, use other designs that provide less flexibility in posing queries (ref. WEB)
Resolution	• Refers to the sharpness and clarity of an image. The term is most often used to describe monitors, printers, and bit-mapped graphic images. In the case of dot-matrix and laser printers, the resolution indicates the number of dots per inch. For example, a 300-dpi (dots per inch) printer is one that is capable of printing 300 distinct dots in a line 1 inch long. For graphics monitors, the screen resolution signifies the number of dots *(pixels)* on the entire screen. Printers, monitors, scanners, and other I/O devices are often classified as high resolution, medium resolution, or low resolution. The actual resolution ranges for each of these grades is constantly shifting as the technology improves (ref. WEB)
Scanner	• Device that converts *Analogue images* into digital data (ref. NOD/GraDoc)
Shadings	• Colours or shades of grey (usually transparent) representing information to be superimposed on a *base-map* (ref. GraDoc)
Signature	• A distinctive pattern or characteristic by which something can be identified (ref. NOD)
3-D Laser scanning	• Consists in the conversion of an object surface into digital 3-D co-ordinates (x,y,z). When RGB (red,green,blue) laser lights are used, the co-ordinates contain RGB colour values in registration to the 3-D co-ordinates (ref. NRC of Canada)
Vectorized file	• A digital file encoded as formulas in which each single point is exactly defined with at least two numbers (dimensions), allowing the measurement of distances and areas (ref. GraDoc) **Comment:** see also *Raster file or Raster image*
VRML	• short for Virtual Reality Modelling Language; pronounced ver-mal. VRML is a specification for displaying 3-dimensional objects on the World Wide Web. You can think of it as the 3-D equivalent of HTML. VRML produces a hyperspace (or a world), a 3-dimensional space that appears on your display screen. And you can figuratively move within this space. That is, as you press keys to turn left, right, up or down, or go forwards or backwards, the images on your screen will change to give the impression that you are moving through a real space (ref. WEB)

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THE CD-ROM: TECHNICAL AND COPYRIGHT INFORMATION AND CONTENTS

BACKGROUND

This volume is accompanied by a CD-ROM which contains HTML files related to the papers published in the book. In most cases, the demonstrations elaborate on the content of the printed papers, and should be seen as complementary to them, providing additional visual material. In other cases, they are totally rewritten contributions about the same subject but with different formatting and some new material, including video or interactive models.

Because of the technical difficulties of carrying out language editing on this material, it was decided to publish the demos as the authors supplied them. Some material is still in the original language (especially where taken from screen views), and there may also be some minor errors in English.

Despite considerable effort, some technical deficiencies might remain, such as inactive links. Furthermore, the CD-ROM is a compromise between speed and resolution, so that some recordings (especially VRML models and movies) are at a lower resolution compared to the original files. Depending on the computer used, it might still take some time to load the heavier files. Please also note that, due to the technical impossibility of creating 'screen captures,' the images for F. Petrignani's demonstration on the Sistine Chapel were taken by conventional photography, which explains their relatively low quality; this is also a result of the curving of the monitor.

Some papers call for additional software. For best results, you should use Microsoft Internet Explorer 4.0 or higher or Netscape Navigator 4.0 or higher, and install additional plug-ins. We have included installation programs for CosmoPlayer 2.1, QuickTime 4.0, LivePicture, Shockwave, (see the Software Folder at the root level of this CD). Installation is very easy, but in some cases (QuickTime and Shockwave), you need a computer with an Internet connection to be able to download some files. We suggest installing all this software before reading the contents.

This CD can be read on a Macintosh computer, using the appropriate versions of Microsoft Internet Explorer or Netscape Communicator. You should install QuickTime, Shockwave and the CosmoPlayer plug-ins. Mac versions of those plug-ins have not been included here.
For any question about the book or the papers, you should contact the individual authors.

CONTENTS OF THE CD-ROM

DIGITAL GRAPHIC DOCUMENTATION AND DATABASES: CRITICAL EVALUATION / CASE STUDIES (PART II)