

Final Activity Report
EPOCH Network of Excellence

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EPOCH

**Excellence in Processing Open
Cultural Heritage**

Network of Excellence
Information Society Technologies

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PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	



EPOCH has been a Network of Excellence funded by the European Union under the Sixth Framework Programme. The network integrated about a hundred European cultural institutions joining their efforts to improve the quality and effectiveness of the use of Information and Communication Technology for applications to the tangible Cultural Heritage of monuments, sites and museums. This report summarises the activities and achievements of EPOCH.

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A view over the site at Karnak, Egypt

Executive Summary

EPOCH has been a Network of Excellence in Framework 6, co-funded by the European Commission under the IST program. The Network consisted of about a hundred



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European institutions joining their efforts to improve the quality and effectiveness of the use of Information and Communication Technology for applications to the tangible Cultural Heritage of monuments, sites and museums.

Participants included university departments, research centres, heritage institutions, such as museums or national heritage agencies, and enterprises, together endeavouring to overcome the fragmentation of research in this field.

This publication is a summary of EPOCH, describing what we set out to do, how we set about it and the achievements of the project. EPOCH has been a massive and

complex venture with several hundred researchers associated with the Network and dozens of active lines of research being pursued. This book is necessarily a summary of the work of the project, but there are pointers throughout to sources of more detailed information.

One result of the project is around 30 EPOCH publications produced over the 4 years of the activity and well over 150 scientific papers (see Appendix). The EPOCH website will remain available for at least 2 years and includes a list of them all, as well as downloadable versions of the EPOCH publications. It has been agreed in principle that they will be made available online through the Eurographics Digital Library (www.eg.org) and on the UNESCO website (whc.unesco.org), which are expected to be maintained in the long term.

Objectives

Perhaps the greatest challenge (and achievement) of the EPOCH project was that it brought together specialists from diverse fields, made them collaborate, and thereby fostered a much deeper interdisciplinary understanding of the diverse research problems in different fields.

Cultural Heritage is a very demanding domain for the application of ICT for a number of reasons:



Figure 1. Stones in storage at Karnak, carved on more than one side from re-use. How would/should these be presented or used in digital reconstruction?

✧ CH is a broad field.

CH ranges from the archaeologists excavating in the field; to the historian developing interpretations and building hypotheses about historic facts and relations; and to the museum curator who chooses from the available information to set up an exhibition. Other actors come from diverse fields in engineering: from photogrammetry (geodesy); to computer

vision; to 3D scanning professionals; but also to semantic technologies; to user interface design; to interactive AR/VR, and many more. But besides these main fields more specialized applications exist – for example the assembly of fragmented objects, and the particular requirements of underwater archaeology.



Figure 2. The challenge of semantics – a carving with a mix of hieroglyphics and the appearance of a spreadsheet. What do you record? What's the significance? Physical objects; broken parts; surface damage; Hieroglyphics; Semantic content?

✧ Archaeology is a destructive science.

In order to get access to strata with older remains deeper in the ground, the strata from more recent periods have to be removed. The original information from the upper strata will never again be accessible: each period of Troy can only be excavated once. This puts great emphasis on faithful recording and documentation. The problem is that it may become apparent only much later that a particular piece of information would have

been of great value. For this reason as much data as possible from each stratum must be recorded, in principle, and sustainably stored – even data that may seem irrelevant at the time. CH professionals are understandably reticent about experimenting in this one-off opportunity with technologies whose effectiveness is not tried and tested.

✧ **Overwhelming masses of data.**

Archaeological sites of towns and cities are typically quite large in extent, typically ranging from several hectares to a few square kilometres. Faithful recording, e.g., laser scanning at millimetre precision, over the whole site is not feasible, not only because of the data acquisition cost, but also because it requires extremely efficient data mining techniques to avoid the “data grave” phenomenon: data that cannot be accessed are effectively buried and lost – and hence useless. Some parts of such sites, e.g. bas reliefs carved on a block of stone, may require sub-millimetre precision; in extreme examples, like the huge sites in Karnak (Egypt) or Angkor Wat (Cambodia), sites may



Figure 4. Refurbished element – what should be the significance in a digital model of the “original”?

be literally covered with stone fragments carrying carvings and extending to several square kilometres. Balancing accessibility, accuracy and storage requirements remains a problem.

✧ **CH institutions are not rich.**

Digital technology is coming down in price, but acquisition devices such as laser



Figure 3. Part of a Bas Relief at Angkor depicting stories of war.

scanners are still quite expensive, and even digital cameras are sometimes considered too brittle for the field. The highest cost, however, is that associated with providing trained, specialized personnel for the digital equipment. In addition quite often the post-processing costs can be higher than the acquisition cost. New devices such as camera domes have a huge potential for the automatic acquisition of smaller finds, but much research is still needed to develop more automated approaches suitable for use by staff who do not have, or require, the same level of technical competence and training.



❖ **CH professionals are conservative – for good reasons.**

Many cultural heritage professionals have been, and continue to be, justifiably suspicious of the promises of technologists whose track record does not encourage confidence that the exotic tools proposed will either mesh smoothly with the sector's workflows or be sustainable in the longer term. Technological developments have been littered with examples of "neat ideas", developed as research exemplars but which never become robust deployable solutions and rapidly end up obsolete. Technologists need to be sensitive to this.

A holistic roadmap leading to the development of applications of ICTs integrated with working practices in CH could not have been devised when EPOCH started; but it is much clearer now. This

is a real achievement, since it represents a genuinely inter-disciplinary effort. We believe that EPOCH has established a degree of trust that can be used in taking the field forward over the coming years, provided that impetus and investment are maintained.

The overall objective of the network has been to provide a clear organisational and disciplinary framework for increasing the effectiveness of work at the interface between technology and the cultural heritage of human experience represented in monuments, sites and museums. This framework would encompass all the various work processes and flows of information from archaeological discovery to education and dissemination. It would identify where the bottlenecks in the end-to-end process are currently located and this in turn would allow

identification of research priorities. Plans to achieve sustainability of the developments have also been an integral part of the project.

A major strand in the development of the network has been a program of activities to deliver an integrated infra-

Figure 5. Part of a temple at Ankor under reconstruction in a project which started in 1908.



structure in support of the production of applications to communicate aspects of cultural heritage to different end-user markets (e.g. education or tourism). This infrastructure has been designed to bring together the localised results in individual technologies and harmonise the solutions into progressively more integrated “tool chains”. The compatibility of the tools is designed to be achieved through documented and standardised data formats and a common information store, rather than through adoption of a single common software environment. This also allows extensibility through the development of tools which can access the common data formats and deliver results compatible with those formats.

A clear thread through all activities in the network has been to recognise different disciplinary perspectives and the value of cross-disciplinary fertilisation of ideas, skills and understanding. This has been reflected in the network’s membership, in the structure of its organisation and in the mechanisms for defining priorities within the Joint Program of Activities.

By bringing the disciplines and constituencies into a closer working relationship, the Network has effected a fundamental, positive change in the state of the art. This has been accomplished through enhanced communication, thereby avoiding

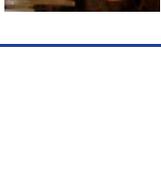
situations either in which technologists work on problems for the public cultural sphere that have little practical applicability – or in which cultural heritage specialists re-invent technologies that have been tried and tested elsewhere, and perhaps even found wanting. The network’s primary goal was to encourage all groups working on problems which have potentially sustainable practical applications in achieving technical objectives, underpinning sustainable operations and organisations, and effectively communicating cultural heritage.

A major objective of the network has been to re-emphasise continually a holistic, interdisciplinary view of the role of all disciplines contributing to a sustainable sector, to the benefit of the quality of life in Europe and of its citizens. The impact on quality of life is by no means limited to the economic contribution of on-site venues and secondary franchised marketing. It extends to the secondary effects on the sense of citizenship and behaviour of individuals.

This publication outlines the major achievements of the project, and includes a list of all the publications that were produced over the 4 years of the activity. These publications will remain available on the EPOCH website for at least 2 years and through the Eurographics Digital Library (www.eg.org) and on the UNESCO website (whc.unesco.org).

EPOCH Board of Directors

The Board of Directors managed and led the activities of the Network of Excellence. It was chaired by a coordinator and consisted of a mixture of Directors with specific responsibilities for portfolios of business or representing constituencies. The Board of Directors met twice a year in preparation for the General Meetings of the Assembly. The Board membership was:

	David Arnold WP1 Coordination and Executive member University of Brighton, UK		Franca Garzotto Politecnico di Milano, Italy
	Daniël Pletinckx WP2 Coordination and Executive member Visual Dimension, Belgium		Erzsébet Jerem Hungarian Academy of Sciences, Budapest Hungary
	Luc van Gool WP3 Coordination and Executive member KU Leuven, Belgium		Maria Pia Guermandi Istituto Beni Culturali Regione Emilia Romagna, Italy
	Franco Niccolucci WP4 Coordination and Executive member PIN - University of Florence, Italy		Dieter Fellner Fraunhofer Institute for Computer Graphics Research (IGD), Germany
	Nick Ryan Executive member University of Kent at Canterbury, UK		Halina Gottlieb Executive Member Interactive Institute, Sweden
	Paolo Cignoni Non Director Executive Member I.S.T.I. - C.N.R		Brian Smith The European Association of Historic Towns and Regions, UK
	Irina Oberländer-Tarnoveanu CIMEC, Romania		Steve Stead Paveprime Ltd, UK
	Andrea Caiti ISME, Italy		Cinzia Perlingieri Elected Member University of Naples, Italy

EPOCH Members

Participant name	Country	Participant name	Country
▶ University of Brighton	UK	▶ Fraunhofer Gesellschaft zur Förderung der Angewandten Forschung E.V.	Germany
▶ PIN srl – Servizi didattici e scientifici per l'Università di Firenze	Italy	▶ Rheinische Friedrich-Wilhelms Universität Bonn	Germany
▶ Ename Center for Public Archaeology and Heritage Presentation	Belgium	▶ University of Tübingen	Germany
▶ Katholieke Universiteit Leuven	Belgium	▶ Foundation of the Hellenic World	Greece
▶ Technische Universitaet Graz	Austria	▶ INTRACOM S.A. TELECOMS SOLUTIONS	Greece
▶ Technische Universitaet Wien	Austria	▶ GeoAnalysis sa	Greece
▶ Leopold Franzens Universitaet Innsbruck	Austria	▶ Technical University of Crete	Greece
▶ Virtual and Augmented Reality Technologies NV	Belgium	▶ Synthesis & Research Ltd	Greece
▶ Axell Communication srl	Belgium	▶ Advanced Computer Systems A.C.S. – S.P.A.	Italy
▶ New Bulgarian University	Bulgaria	▶ Politecnico di Milano	Italy
▶ Gastiburu SL	Spain	▶ Alma Mater Studiorum - Università di Bologna	Italy
▶ MAP - CNRS	France	▶ Università degli Studi di Genova	Italy
▶ Université de Toulon et de Var	France	▶ Ducati Sistemi S.P.A.	Italy
▶ Albert-Ludwigs-Universitaet Freiburg	Germany	▶ Consiglio Nazionale Delle Ricerche	Italy
▶ Technische Universitaet Braunschweig-Institut für Computergraphik	Germany	▶ 4site srl	Italy
		▶ HeritageSolutions	Netherlands
		▶ Hogeschool van Utrecht	Netherlands

Participant name	Country	Participant name	Country
▶ Universitetet i Oslo	Norway	▶ Paveprime Ltd	UK
▶ Insitituto Polytecnico de Tomar	Portugal	▶ Planetek Italia S.R.L.	Italy
▶ Universitat Autonoma de Barcelona	Spain	▶ Instituto Superior Tecnico	Portugal
▶ Universitat de València. Estudi General	Spain	▶ Kungliga Tekniska Högskolan	Sweden
▶ Universidad de Jaén	Spain	▶ Oxford ArchDigital Ltd	UK
▶ Diputación Provincial de Jaén	Spain	▶ Istituto per i Beni Artistica, Culturali e Naturali della Regione Emilia Romagna	Italy
▶ Universidad Politecnica de Madrid	Spain	▶ Archaeolingua Alapítvány	Hungary
▶ The Interactive Institute II AB	Sweden	▶ The European Academy of Sciences and Arts	Austria
▶ Karlstad University	Sweden	▶ Institutul de Memorie Culturala	Romania
▶ Eidgenossiche Technische Hochschule Zurich	Switzerland	▶ Ministerie van de Vlaamse Gemeenschap	Belgium
▶ Université de Geneve	Switzerland	▶ UniRel srl	Italy
▶ Ecole Polytechnique Fédérale de Lausanne	Switzerland	▶ Tekniska museet (National Museum of Science and Technology)	Sweden
▶ University of Kent	UK	▶ Stichting Bedrijfsregio Kop van Noord-Holland	Netherlands
▶ University of York	UK	▶ Ciência Viva – Agência Nacional para a Cultura Científica e Tecnológica	Portugal
▶ University of Bristol	UK	▶ Georg-August-University Göttingen	Germany
▶ Brunel University	UK	▶ Scientific Research Centre of the Slovenian Academy of Sciences and Arts	Slovenia
▶ University of East Anglia	UK		
▶ The University of Surrey	UK		
▶ The University of Warwick	UK		
▶ The University of Sussex	UK		

Participant name	Country	Participant name	Country
▶ Rijksuniversiteit Groningen	Netherlands	▶ The Brunswick Town Charitable Trust (The Regency Town House)	UK
▶ Département des Recherches Archéologiques Subaquatiques et Sous-Marines	France	▶ Salzburg Research Forschungsgesellschaft mb.H	Austria
▶ The University of Hull	UK	▶ Ministry of Education, Culture and Science (OCW), Rijksdienst voor Archeologie, Cultuurlandschap en Monumenten	Netherlands
▶ University of Patras	Greece	▶ Visual Dimension bvba	Belgium
▶ Imagination Computer Services GesmbH	Austria	▶ Kings College London	UK
▶ Instituto Tecnológico de Informático	Spain	▶ Consorzio Interuniversitario per la Gestione Del Centro Di Calcolo Elettronico Dell'Italia Nord Orientale	Italy
▶ National Museums of Scotland	UK	▶ Centre de Recherche et de Restauration des Musees de France (Centre for Research and Restoration of the Museums in France, C2RMF)	France
▶ University of Cape Town	South Africa	▶ Foundation for Research & Technology, Hellas	Greece
▶ Culture, Heritage & Development - International	Belgium	▶ Higher Technical Institute, Cyprus	Cyprus
▶ Conseil Général de la Côte d'Or (Parc Archéologique d'Alésia)	France		
▶ Università della Svizzera Italiana (USI)	Switzerland		
▶ Visual Acuity Limited	UK		
▶ Università degli Studi di Napoli - L'Orientale	Italy		
▶ European Association for Historic Towns and Regions	UK		



Approximate geographic spread of EPOCH's European partners



Breakdown of EPOCH Researchers

	Dec 2003		Nov 2004		Mar 2007		Feb 2008	
RESEARCHERS								
Male	95	63%	211	70%	323	72%	257	69%
Female	56	37%	91	30%	127	28%	114	31%
DOCTORAL STUDENTS								
Male	333	70%	110	68%	116	69%	75	67%
Female	146	30%	51	32%	53	31%	37	33%



Gender Representation

Achievement of gender equality in scientific excellence is a long-term process in which existing social and political norms and rules must undergo profound changes. It also implies a new way of thinking in which the stereotyping of women and men no longer limits their opportunities or continues to reward just one of the two sexes.

The EPOCH experience, yet positive for most women colleagues in general terms, is similar to most European Projects and is a reflection of what usually happens in the scientific/academic domain. Nevertheless, indicative of the "EPOCH effort" towards a gender equality is the female representation in the research groups and decision making bodies.

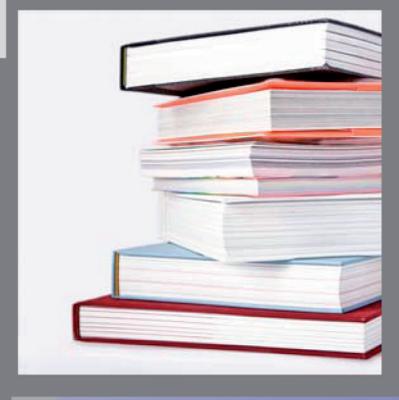
A survey of the gender equality experience in EPOCH indicates some researchers' views:

✧ "My experience in EPOCH project was positive as a whole. My role as member of the board of directors has surely improved my professional

experience." (Maria Pia Guermandi, Istituto Beni Culturali della Regione Emilia Romagna)

✧ "...the training branch of Epoch proved very valuable. I was able to attend a funded training course on digital preservation and dissemination of cultural heritage in the summer of 2005. This allowed me to meet and work with other individuals from the same research area. Now, 2 ½ years later, I have just started a fellowship at the institution where this training course was held, so in the long term Epoch helped a lot!" (Maria Sifniotis, Research Fellow, VAST Lab, PIN, University of Florence)

✧ "My experience in EPOCH has been very positive. I have learnt greatly not only in my technical discipline but I have also been exposed to a wide variety of interdisciplinary professionals." (Karina Rodriguez-Echavarria, Research Fellow, University of Brighton).



How EPOCH work was organised

EPOCH has been structured into three major activities with a fourth managing the project. They are the following:

✧ Integrating Activities

These activities were aimed at integrating understanding of all relevant aspects of the disciplines and perspectives which contribute to the holistic view of the application of ICTs to Cultural Heritage.

✧ Jointly Executed Research

These activities targeted the establishment of compatible tools for processing and refining data collected about tangible cultural heritage. Considerable emphasis was placed on developing sample prototype applications both to demonstrate the roles of the tools, but also to act as a catalyst in discussion with CH professionals and policy makers about the potential future directions of development of both the tools and the workflows that they might help to sustain.

✧ Spreading Excellence

EPOCH's efforts in this area were a mix of coordinated responsive actions and a set of dissemination activities in which activities elsewhere were brought to the attention of appropriate groups and their feedback obtained.



Daniel Pletinckx,
Coordinator of Integrating
Activities



Luc Van Gool,
Coordinator of Jointly
Executed Research



Franco Niccolucci
Coordinator of Spreading
Excellence



Integrating Activities

EPOCH has established and improved integration between technical and scientific communities and the other partners, who span a wide range of organisational types – from national and regional cultural heritage organisations to museums and governmental organisations and a range of companies.

Achievements

Sector Watch

The Sector Watch activity has converted the knowledge available in the EPOCH network, and new research results, into accessible publications on pilot projects and early implementations. These case studies have been named “knowhow books”. Ten knowhow books were produced, organised in three categories (heritage sites, monuments, museums). 500 copies of the

museum volume of five knowhow books were printed, complemented with a volume on guidelines for cultural heritage professionals in the use of ICT.

Sector Watch Activity also developed a wiki-based Knowledge Base framework, based on content that had been collated from within the Network. This Knowledge Base is online at the EPOCH website and the her-IT-age.net website (<http://her-it-age.net/>) and is suited for further continuous update by the expertise centres. It provides both a wide range of knowledge on ICT use in CH and links to online resources and evaluations of projects in the field.





The Knowledge Base was initially a crucial instrument in the knowledge transfer activities of the expertise centres established by EPOCH, but will also continue to serve the CH community through registered login. The Knowledge Base provides information on the use of ICT rather than on the research issues, and collects information about results and outcomes of CH projects that use ICT. In this way, it complements the knowhow books.

Research Agenda

A Research Agenda has been produced after major consultation with both EPOCH and non-EPOCH experts. Issues considered in the Agenda include technical research topics, CH business mechanisms, product life cycle, maturity and adoption levels of ICT in cultural heritage and socio-economic impact modelling. The Research Agenda lists also a major set of recommendations for six domains, providing a guiding role for research in the cultural heritage and ICT domain in the coming years. The Research Agenda will act as a reference document for the long-term development of the sector, while the other activities in WP2 focus on the short term development of the sector.

A plan for maintaining the Research Agenda has been incorporated in the thematic clusters, which are associated with the EPOCH Centres of Expertise.

Socio-economic impact

Socio-economic impact models have been developed for ICT investment at heritage sites, the impact of the site itself and the impact of the heritage city, with reference to ICT. These three principal models highlight the multilevel impact modelling approach that was taken in this activity. The models have been further developed into training tools and have even been applied to both heritage organisations and closely allied sectors such as social enterprise. Furthermore, three publications have been produced around the issue of socio-economic impact and ICT at heritage sites, and three highly successful *Heritage Impact* conferences have been held. Recently a workshop was conducted at the UNESCO World Heritage office in Paris using EPOCH training material. This has resulted in the publication of a UNESCO book.

Socio-economic impact modelling is a key element in the creation of trust in using ICT in CH. The holistic approach developed allows for the creation of a well documented workflow to outline, predict or measure how CH projects impact their environment



and the population involved. These are important tools that can be used when consulting policy makers, informing the local population or making decisions when important CH related investments need to be made. The models developed are very versatile and have specific ICT investment modules, as such they can play a paramount role in the support of the implementation of ICT based projects in CH.

Brokerage

The Brokerage Schemes Activity was focused on supporting effort on the Network of Expertise centres. The major efforts in this activity focused on the creation and support of thematic clusters and on the description of business models that support knowledge and technology transfer for SMEs.

Thematic clusters are regular, international meetings (once or twice a year) of CH professionals, ICT researchers and SMEs concerning a particular domain. In the Brokerage Activity, clusters have been developed around Location Based Services, on Archaeological Information Systems, on Serious Gaming and on 3D Content. The aim is to make a mix of presentations that both show research projects and results of CH projects that use that specific technology, and to discuss the

further development and application of that technology.

The strategy behind this uptake is twofold. On one hand, we need to reach early adopters, CH management and the younger generation to stimulate the adoption of new technologies, to layout business models and workflows and to create successful pilot projects and best practice descriptions. Once these are available, they need to be disseminated to the wider CH community (through the expertise centres and other channels) to create a pull mechanism instead of the push mechanism that is common today. In other words, ICT in CH will only be successful if the sector itself is convinced of the added value of ICT.



Supporting SMEs

The Encouragement of SME Involvement Activity developed and deployed a strategy to encourage the development of a Network



of Expertise linked to local learning groups (clusters) of companies, CH organisations, creative industries and research organisations to provide mutual support, increase understanding of the sector, identify opportunities for development and collaboration and define a program of education and training in support of the development and improvement of the CH+ICT sector.

The partners in this activity have worked on defining and testing the different aspects of creating a Network of Expertise and have evaluated the ongoing activities of the operational expertise centres. Candidate centres have received training and support in holding a start-up meeting.

An important outcome of the activity was the creation of methodological guidelines for the creation and operational aspects of the Network of Expertise. An important aspect of that is the creation of a strategy for continuous monitoring and updating

of the stakeholder needs through a “thematic cluster” approach, which allows the demonstration of the state-of-the-art, present related projects, product offerings and developments and monitor the evolving needs of the sector for one specific domain. Thematic cluster meetings are held once or twice a year and differ from existing conferences in several aspects: they are focused on knowledge transfer and practical application, not on academic publications; they focus on one specific domain in all its aspects and; they bring together researchers, users and solution providers.

Another focus of the activity was making CH experts, and especially CH managers, aware of the opportunities and possibilities of the use of ICT in cultural heritage, as we still see a slow take up of existing technologies and a poor understanding of emerging technologies. This knowledge transfer has been tested through two approaches. The first approach is the creation of knowhow books (see above), the second is the creation of a training strategy that offers knowledge on three levels: management, seminar and hands-on level. This means that a certain package of knowledge is made available through three different kinds of training sessions. A management training session targets upper management takes 1–2 hours and deals with the concepts, the impact of the presented technology/methodology on the organisation, the competencies, budgets and time spans required to implement. A



seminar level training takes half a day to a day, targets middle management and cultural heritage experts and focuses more on the opportunities and workflow of the technology/methodology. A hands-on level training takes 3 to 5 days, targets cultural heritage staff and focuses on mastering the technology/methodology presented and its associated workflow in detail.

The Integrating Activities all aim to create a system that supports the use of ICT in CH on a European level in a scalable and sustainable way. These activities have defined, tested and started a framework, called the Network of Expertise her-IT-age.net, that is linked to the local cultural structures within Europe and that gets most of its funding through this local level. European funding will be pursued to define and establish such a network, but a combination of this local funding and membership and event fees

collected by the network are expected to maintain the structure in the longer term.

By establishing several types of brokerage (first line consulting, interdisciplinary laboratories, incubators), pilot projects are supported, workflows and best practices are established and technology transfer to SMEs is organised.

The expertise centres, that organise these activities, were also a major driving force behind a sector wide Knowledge Base that is open for use and input to all registered, professional users in the CH+IT domain. Socio-economic impact modelling and innovation management (as established in the learning clusters of the expertise centres) are major research results originating from EPOCH that will underpin the use of ICT in real world CH projects.



Jointly Executed Research

Within EPOCH, the goal for the jointly executed research work package was the analysis, research, and development of digital tools for the field of Cultural Heritage. Emphasis was placed on defining a common infrastructure that guaranteed interoperability, integration and sustainability of these tools.

Achievements

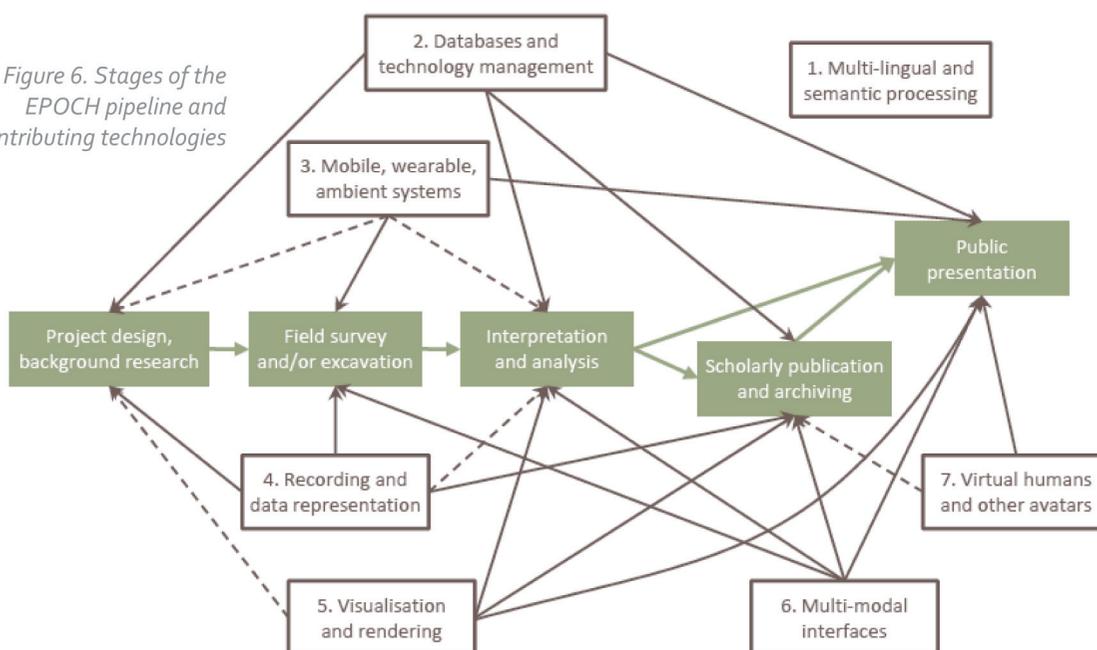
This work package dealt with tools which handled spatially organised data, including data which represents 3D environments and artefacts and the associated data sources and descriptions. Some of the tools were targeted explicitly at the acquisition, organisation and manipulation of metadata associated with archaeological records and museum artefacts. The interoperability of chains of tools was targeted by adopting

standardised data types and formats along with underpinning common software environments. These included adoption of CIDOC-CRM compliant XML Schema in developing tools for metadata handling; using PROTÉGÉ¹, a free Open Source ontology editor and knowledge-base framework; adopting OpenSG as a widely used visualisation environment; and so on.

The jointly executed research activity first defined the types of transformations applied to the cultural heritage data as it was captured, analysed, stored, and presented to users. At each stage of this pipeline the critical contributing technologies were identified which would form essential support to tools designed for each stage (figure 6). This led to the definition of the concept of a Cultural

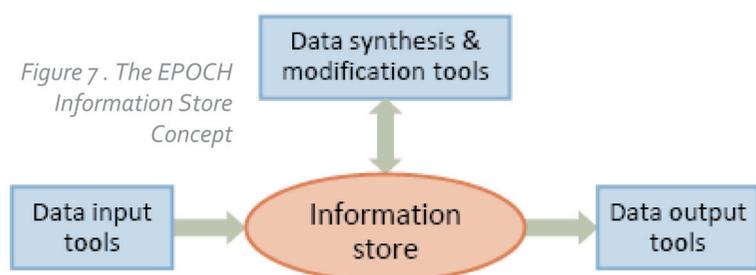
¹ <http://protege.stanford.edu/>

Figure 6. Stages of the EPOCH pipeline and contributing technologies



Heritage Information Store, with tools progressively accessing digital artefacts from the store, refining their content and returning the refined data to the store in elaborated form but remaining incompatible formats and retaining information about the manipulations to which the data has been subjected (Figure 7).

Figure 7. The EPOCH Information Store Concept



The Cultural Heritage domain is very demanding for a number of reasons. The use of information and communication technology (ICT) is still immature in CH, in contrast to many other industrial and research domains where complete, or heavy, digital

workflows are common today. A number of proprietary or research software tools exist, but there is no coherent integration, either of standards and procedures, or of software and data structures – which is required to meet the central goal of sustainability. During the EPOCH project, a number of factors contributing to this phenomenon have become much clearer, which was itself a major technical result of the project, since their identification permits the definition of strategies to overcome them.

Having defined the various stages of transformation of data from capture to presentation, EPOCH sought to ensure that the Common Infrastructure provided exemplars of tools to assist with every stage of this processing in ways which were compatible with other tools in the chain of processing. The work proceeded

by identifying existing tools and prototypes which could contribute to the processing chain and refining these for enhanced compatibility; and by identifying gaps in the chain where there were no suitable prototypes and developing NEW TOols Needed, or NEWTONs, which would fill in the gaps.

The prototypes developed under this activity took the form of showcases of existing technologies in year 1 of EPOCH and then were augmented and deployed through the concept of the Interactive Salon – a touring exhibition which was brought to several venues across Europe during the last year of the project. Its deployment provided a useful forum for discussions on future directions which became one strand of the inputs fed back into the development in the EPOCH research agenda.

Tools developed within the jointly executed research work package include:

CityEngine



The CityEngine is a complete software suite, for the fast creation of 3D building models. Following the principles of procedural modeling, it generates compact models on the basis of the sequential application of a series of grammatical rules. Each architectural style comes with its own

rule set. Starting from a crude, volumetric description, subsequent rules gradually expand the model obtained so far by replacing structures by more detailed ones. The resulting models are highly structured and compact, and the visual realism which can be achieved at limited time investment is unrivalled. The CityEngine comes with an extensive user interface, which allows for swift interactive changes.

Arc3D

This tool enables users to upload images of a scene or object to the ARC service over the Internet. A 3D reconstruction is produced fully automatically. Once the



result is ready, the user is notified via e-mail that they can download the result, via ftp. The result consists of the 3D information as well as the relative vantage points from where the uploaded images were taken and the settings of the camera(s). The 3D information can be downloaded in any of a series of popular data formats.

Minidome

This apparatus is a hemispherical structure, with 264 white power LEDs. There



is one overhead camera, focused on the centre of this dome structure. The many

light sources, combined with a robust photometric stereo algorithm, allow for the automatic and accurate extraction of the object's colour, local surface orientation and depth map. The dome itself consists of 4 shells, which can be easily assembled or disassembled. It is an easy and cost-effective mechanism for high-quality acquisition of CH artefacts with complex material.

IMODELASER and UPGRADE

These tools deal with 3D data acquisition by means of combinations of different types of sensors and under different environmental conditions. IMODELASER concentrates on 3D modelling based on terrestrial images and laser scanning. On the other hand UPGRADE concentrates on data gathering and representation of underwater sites. Thus it automates the generation of 3D models from underwater video, acoustic and navigation data.

MeshLab

MeshLab is an open source, portable, and extendible system for inspecting, processing, editing and converting of



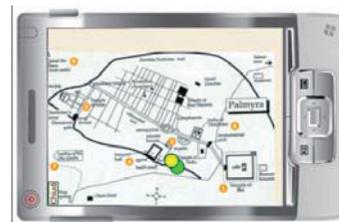
unstructured triangular meshes. It supports a wide variety of 3D formats and allows sophisticated automatic cleaning and repairing tasks. Thanks to its vast audience (thousands of active users) MeshLab has an active open source community that actively contributes to the base code.

AMA and MAD

AMA is a tool created for mapping existing archaeological datasets, including excavation data, museum collections and free text data, to a CIDOC-compliant format. CIDOC-CRM is a standard ontology providing a rich and powerful data structure that simplifies the process of integration and the interoperability between existing and future archives. In addition, MAD is an application designed to store, manage and browse structured and unstructured archaeological datasets encoded in a semantic format, such as CIDOC.

MobiComp and Cimad Application Broker

These tools provide components to support



and coordinate context-aware applications in the Cultural Heritage

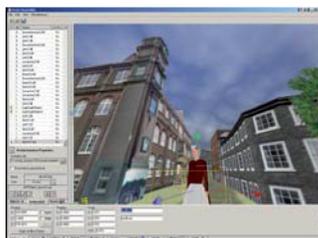
domain. The main component is MobiComp, a framework to store, retrieve and aggregate contextual information (for example, people, exhibits, devices, sensors). CIMAD supports heterogeneous device types with different usage models.

VHDPlus

VHDPlus is an open source, fully component oriented simulation engine and software middleware solution for the domain of VR/AR and virtual character simulation. It relies heavily on multiple, well established Object Oriented design patterns, uses C++ as the

implementation language and Python as a scripting language.

Scene Assembly Toolkit



This is a toolkit for 3D scene creation. This toolkit supports the user through an assembly pipeline by offering components

to integrate city environments populated by avatars.

Epoch Viewer

It is a tool for interactive display and exploration of 3D scenes containing digital 3D artifacts. It is not only a viewer for static pre defined scenes but it also allows composing, editing, and saving 3D scenes.



It has an integrated scripting language that allows attaching scripted behaviour to each object, which can even be used to realize 3D user interfaces.

For more information on this tools see Appendix.

For accessing the
EPOCH tools,
please visit:

<http://www.epoch.eu/tools>





Spreading Excellence

EPOCH has considered dissemination as one of its main tasks, dedicating to it a substantial amount of its budget. Dissemination has taken place through:

- ❖ The EPOCH web site
- ❖ Events, both organized by EPOCH and attended/in collaboration
- ❖ Publications
- ❖ Training activity

Achievements EPOCH Website

The EPOCH web site (www.epoch.eu) contains all information related to the project. This information includes news and events, general information, common infrastructure tools, as well as EPOCH publications and multimedia. The website will be maintained at least until March 2010.

EPOCH website	
Total number of (distinct) visitors:	150,000
Number of different countries accessing the sites:	130
Total number of hits:	4,800,000
Total volume of downloads:	103 GB

Events

The events activity of EPOCH has produced a very large presence at Conferences, Symposia, Exhibitions and Workshops. Two events were the cornerstones of EPOCH event activities



- VAST (Virtual Reality Archaeology and

Cultural Heritage) and CAA (Computer Applications in Archaeology). The VAST conference has been organized in Brighton in 2003 just before the project start. In 2004 it took place in Brussels. In 2005 it was organized in Pisa. VAST2006 was organized in Nicosia and VAST2007, the last of the EPOCH period, in Brighton again. The major

core issues of the Symposia have been the measurement of socio-economic impact, with special reference to the impact of information technology at heritage sites. The symposia have also been used to provide training for practitioners in the field. These highly focused events have proved popular and have formed the basis for three publications. A roundtable conducted with UNESCO in January 2008 explored the issue of socio-economic impact at World Heritage Sites and will lead to the publication of a further book.



2008 EPOCH event was the symposium organized by EPOCH in Rome in February 2008. EPOCH has also participated in a large number of events organized by others, giving presentations about its activity or managing a stand, and distributing dissemination material.

EPOCH has successfully created a specialist event for the heritage community called 'Heritage Impact'. These highly successful symposia have run annually since 2005. They have allowed academics, policy makers and practitioners in the heritage field to share the latest thinking on research direction and to consider strategies for improving and evaluating socio-economic impact. The

EPOCH events	
EU countries covered:	20 member states
Countries outside Europe:	India, Japan, Mexico, USA, China, Egypt, Israel, New Zealand, China, Singapore, Taiwan, South Africa, Russia.
Total contacts at EPOCH events:	66,000 Total contacts with professionals
Level of satisfaction at EPOCH events:	92-95 %

EPOCH events have joined a very high scientific quality with a very strong social component. Openness to non-EPOCH partners has favoured spreading EPOCH goals and results to a very wide audience, formed by qualified professionals and as such present key testimonials of EPOCH excellence.

Regional Meetings

EPOCH also organized regional meetings in 2006 and continued in 2007 and early 2008. Often they were organized jointly with the meetings of the Network of Expertise Centers, an activity aimed at sustaining and promoting SMEs and facilitating the creation of Expertise Centres in different countries. Such regional meetings usually involved some 30 selected professionals from outside EPOCH, who were informed of the Project's goals, work and resulted in a context tightly focused on applications and with an audience professionally interested in the results. A few have been organized with a public part, or within a larger event, where attendance has been even wider. Many of these meetings have generated further local activity.

The Interactive Salon

The Interactive Salon was an exhibition about new technologies and concepts for



communication with visitors in the context of cultural heritage. Projects from EPOCH,

CultNat, the Interactive Institute, SICS and the Museum of Far Eastern Antiquities were invited to serve as showcases of how new technology and concepts can improve visitor communication and interpretation at art museums, culture historical museums, science centres and heritage sites.

The Interactive Salon opened at Stockholm City Museum (17th October 2006 - 30th of March 2007). It was then planned to adopt a mobile version of the Salon and exhibit it in different venues in Europe. Afterwards it travelled to Budapest (June to August 2007), Prague (September 2007) where it formed part of the Cultural Heritage theme at Eurographics, Florence (October 2007), Paestum (November 2007) and Brighton (end of November 2007). It has been attended by a large number of visitors, who were requested to "touch the exhibits" and interact with them. Reactions were very positive particularly from the young. Finally a selection of the exhibits was used at the EPOCH symposium in Rome.

Publicity

EPOCH was able to address the media and the general public in several circumstances. Usually interviews were related to major events, and were published in national newspapers or broadcast on national TV. Magazines have published articles, mainly in the occasion of some important event, like VAST.

EPOCH also produced a transportable stand with panels illustrating its goals, activities and the advances in EPOCH's work. Panels were printed on a special plastic material for easy updates. This was used at events whenever possible and proved to be very good in attracting people, particularly when complemented with a projection screen displaying a video on EPOCH results.

EPOCH created since its beginning a set of tools to facilitate dissemination. They included mouse-pads, pens, pencils, and a few items such as rain jackets and sweaters. They were simple reminders of the web site address and addressed no audience in particular. EPOCH also produced some leaflets with essential information on its activities.

Publications

EPOCH has produced a publication series with over 20 titles appearing during the project. All EPOCH publications have been distributed on paper and are also freely available for download from the web site. A list of all EPOCH publications is included as an Appendix.

Training Activity

The need to enhance mobility both for staff and young researchers was an important

consideration for EPOCH. The Network provided grants for this need. Bursaries covered two kinds of scholarships: attendance to short summer courses and short secondments at a partner institution.

EPOCH publications	
Number of books published:	22 + 6 in association
Total number of pages:	more than 3600
Scientific papers originating from EPOCH:	more than 180
Circulation:	300 copies each for manuals and proceedings, 1000+ for reports
The top three publications downloads from the web site:	<ul style="list-style-type: none"> ▲ The Research Agenda 1st Ed 2000 downloads; ▲ SOTU 2000 download; ▲ The London Charter 500 downloads.

During the project eight courses were supported. Thirty-six students received a bursary (of whom 67% were female fellows). A further four received mobility grants (50% of whom were female). Furthermore, a book has been published on the 'Training Offerings and Needs in Europe on ICT Applications to Cultural Heritage'.

The final volume of the State-of-the-Union series includes a case study of Cultural Informatics in Higher Education in France, Greece, Spain and the UK, along with a proposal for an EPOCH syllabus.



Finances

More than 50 EPOCH partners have received contributions from EPOCH funds in undertaking activities on behalf of the Network's Joint Programme of Activities. Most of the other partners have benefitted from funding to attend EPOCH events, and other activities short of employing staff on EPOCH funds and many other organisations have been brought in on an occasional basis to advise e.g. on the Research Agenda or to take part in the local clusters around the Network of Expertise Centres.

The draft final accounts for EPOCH show that the Commission's contribution of 7.88MEuros has been used as a contribution to the 9.052MEuro of eligible costs incurred by the partners. However the funds invested by the Commission in EPOCH can be shown to have leveraged access to resources which are far greater. The four data points listed above give the number of researchers

involved in EPOCH – those named in the original technical annex (prepared in December 03) and three census results undertaken during the funded period. The combined worth of the research activities of these people is much greater than the Commission contribution. These are named researchers, but of course the public dissemination of a Network such as EPOCH will have reached a much wider audience.

The combined effect of unrecovered eligible costs (1.172 MEuro), costs incurred that our ineligible (e.g. permanent staff employed in organisations using the FP6 Additional Cost Model) (estimated at 2.6 MEuro over the period of the contract) and unrecovered indirect costs (estimated at 5.8 MEuro) mean that the consortium co-funding totals almost 10MEuro over the period of the contract.

Adding these estimates of co-funding would mean that the true costs of delivering the EPOCH work plan have been nearer to 17.5MEuro.

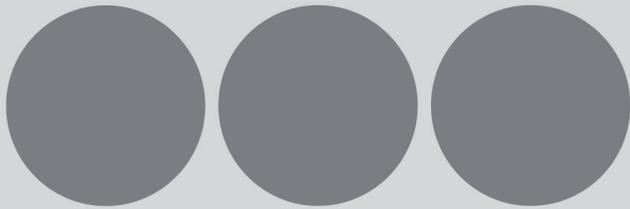
The Value of Associated Research

In addition to the fact that the costs incurred in undertaking the work within EPOCH far exceeded the recovery rates (which is, of course, the natural consequence of the principle of co-funding) Networks of Excellence are a different instrument in that they are intended to influence the work of a wider group of researchers.

The true direct cost (considered a value here) of an average researcher is perhaps 50K Euros per year so the full value of the effort of named researcher whose work has been influenced by EPOCH, but is not part of the direct effort of delivering EPOCH's

work plan, would amount to an addition of over 73M Euro of direct costs. Taking into account the indirect costs of these staff and the value of the research undertaken by the doctoral students associated, EPOCH can be estimated to have undertaken or influenced work to a value of around 194MEuro. This result means that the total gearing on funds used in EPOCH is almost 25 to 1 – for each Euro invested in EPOCH probably 25 Euros of research effort has been influenced.

Given that the number of researchers reported in the network is the equivalent of the staff of a small university an estimated value of almost 50M Euro per year does not seem unreasonable. Overall EPOCH can be seen to have been a highly productive and efficient mechanism for influencing the directions of the sector.



Into the Future

EPOCH has been a large and complex project, encompassing many different organisations and disciplines, each of which has contributed to the success of the project. The Network has also reached a very wide section of the community through regional meetings, technical events, publicity, publications and training.

There has been significant technical progress over a range of technical areas and there are many demonstrations and documented experiments of integration and standards to link the technology areas. As a highlight consider the City Engine, a grammar-based tool for undertaking reconstructions of urban environments. This is an excellent example of an early version of a tool which could with further development, fundamentally alter the approach to analysis that archaeologists take in reviewing the evidence from sites.

Other significant advances have been achieved: in data capture – both in field recording and under controlled conditions using the portable dome on view in the exhibition. The vital issue of assimilating legacy metadata has been addressed through the AMA and MAD tools and experiments have been conducted in using avatars as part of communicating with the public. The open source mesh processing tools is another world-leading contribution to the field. These are only some illustrative highlights of the technical work of the last four years.

Another continuing change is that a significant community has been built which spans disciplines and organisations – a change to which EPOCH has made a large contribution. There have also been real advances in understanding the business



of cultural heritage. Furthermore, there has been considerable knowledge transfer through the Network of Expertise Centres and the development of a Research Agenda for the Application of ICT to Cultural Heritage.

Finally there is a published body of work, which remains available. At the last count

around 180 papers and 22 books had been published by EPOCH partners based on work which has been partially supported through the project. These legacies of EPOCH will benefit the cultural heritage community for many years to come.



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