EPOCH Research Agenda for the Applications of ICT to Cultural Heritage

Full Report

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1 Executive Overview

1.1 Context and purpose of the Research Agenda

EPOCH – Excellence in Processing Open Cultural Heritage – has been a Network of Excellence co-funded under the European Union's Sixth Framework Programme, Priority 2, Information Society Technologies. EPOCH involved 95 partners from a wide range of perspectives, brought together to create a holistic view of the field, integrating and enhancing the previously fragmented efforts in research directed toward intelligent information and communication technologies (ICT) for tangible cultural heritage. The target for these technologies is monuments, sites and museums and the collections of tangible heritage that they hold. Monuments and sites include castles, churches, monasteries, historic town centres, archaeological and other heritage sites.

The Research Agenda is a distillation of debates and expert opinions on necessary future directions that have taken place both within the Network and beyond as this very inter-disciplinary group has shared a journey over increasing cross-fertilization of ideas and perspectives and engaged others in the debates.

EPOCH was founded on a basis of taking the holistic view of the field. As well as ICT researchers, the Network includes researchers in cultural economics, arts and humanities, social studies of cultural participation, cultural administration, regional regeneration and many other relevant fields of research-based guidance of policy making and professional work in the cultural heritage sector.

This multi- and inter-disciplinarity is required to fully address the goals set by the European Union in the **Lisbon Agenda** to make the European knowledge society competitive in sustainable economic growth and employment and a good place to invest, live and work based on a high quality of life.

Europe's rich and diverse cultural heritage makes considerable contributions to the Lisbon Agenda. Cultural landscapes, historic towns, museums, monuments and other heritage sites benefit the European tourism sector, Heritage sites and museums show considerable multiplier effects in employment (one job in cultural heritage generating between five and nine in related sectors), they drive citizen's cultural learning and enjoyment, and also contribute in many other ways to the quality of life and regeneration of European regions and towns.

ICT applications and digital content already add considerably to these societal benefits and there is much more to expect from new and enhanced technological capability. This expectation motivates dedicated funding of collaborative research projects under the **7th Framework Programme** (e.g., the ICT Challenge 'Digital Libraries and Content') and the flagship project of a **European Digital Library** under the i2010 Information Society focus Digital Libraries.

Yet, there is much to do to deliver the potential benefits. EPOCH's effort to provide a common research agenda in cultural heritage and ICT is intended to foster a better cohesion of the communities involved, promote synergies among new initiatives and projects, yield more efficient spending of available funding, and result in better and more sustainable ICT-based solutions.

1.2 Overview of Recommendations

The document takes an holistic view of the interaction between ICTs and Cultural Heritage and reviews the potential benefits deriving from the sector and the ways in which ICTs for the tangible cultural heritage of monuments, sites and museums can contribute to the overall picture. It concludes with a synthesis of the recommendations embedded in the report which groups the recommendations into the following sections.

Group: 1 Embedding inter-disciplinarity
This group of recommendations seeks to set the context which will foster the inter-disciplinarity for research to be of most relevance and have most impact. Together they will encourage the best researchers to engage in the field, enable better projects to be supported and, in the long term, encourage young researchers to enter the field, bringing inter-disciplinarity built-in from their training.

Recommendation: 1.1 **Recognize and value the real benefits of use-inspired basic research in ICTs for cultural heritage applications**

Recommendation: 1.2 **Foster a higher degree of interdisciplinary research and development**

Recommendation: 1.3 **Undertake ontological modelling and systematic, empirically-based analysis from disciplines in which intelligent applications are intended to work**

Recommendation: 1.4 **Promote research that builds in CH operational and user situations**

Recommendation: 1.5 **Disseminate and share research results using approaches which are effective for the CH sector**

Recommendation: 1.6 **Support the development of European Research Infrastructures that are of relevance to research in cultural heritage ICT applications**

Recommendation: 1.7 **Leverage the offer of CH ICT programmes and courses in tertiary education and training as well as opportunities for mobility of young researchers**

Group: 2 Cultural Heritage ICT technical research

This group of recommendations identifies short-, medium- and long-term technical research priorities in the fields of research that have been priorities within EPOCH. For example, when it comes to topics in the preservation and curation of digitized and born-digital cultural resources, the more general aspects are addressed by the research roadmap of the FP6-IST coordination action DigitalPreservationEurope. Here recommendations would address only those aspects that are specific to content where EPOCH had other interests from the processing perspective. 3D content has been a specific concern for EPOCH and a specific sub-section of priorities and recommendations addresses this.

Group: 2.1 RTD for 3D content

3D artefacts and environments are an important part of (digital) cultural heritage, because perceived reality *is* in 3D. The impact of 3D content in the field of cultural heritage is expected to be high, as such content, for example, allows the presentation of rare and fragile (and maybe 'repatriated') museum artefacts as well as very large objects (e.g.,, virtually reconstructed heritage sites and buildings). Moreover, 3D objects offer more potential for interactivity since they can be observed and manipulated from different viewpoints, for instance.

Interest in 3D data acquisition for purposes of documentation, research, virtual reconstruction and presentation is widening. The creation of physical replicas of CH objects (e.g., busts or statues), archaeological artefacts (e.g., carvings) or human remains is also attracting more interest. More and more 3D data will be captured and used for other tasks, for example, as part of regional development planning that includes preservation of cultural heritage sites.

Creating 3D assets involves very different tasks from those for the acquisition of 2D images, and applications using them often require a critical mass to be available to realize the potential value added. Digitization normally needs to take place on-site and non-textual metadata needs to be integrated for effective management, search and retrieval, and other 3D data processing. Current tools are still inadequate for capturing some classes of artefact. There are, therefore, many challenges in creating a 'critical mass' of high-quality 3D content. Thence the efforts in the EDL initiative to build large-scale digital libraries of cultural heritage have not so far given priority to acquiring 3D assets.

Recommendation: 2.1 **Advance the state of the art in 3D digitization tools for 3D shape, surface type and material acquisition, investigating both active and passive acquisition methods and improving the range of artefacts that can be captured at reasonable cost**

Recommendation: 2.2 **Develop tools for the integrated management of the metadata related to 3D artefacts**

Recommendation: 2.3 **Develop tools for the analysis of 3D artefacts and associated information**

Recommendation: 2.4 **Develop intelligent tools for 3D acquisition**

Recommendation: 2.5 **Exploit the opportunities provided by procedural modelling**

Recommendation: 2.6 **Develop easy-to-use authoring tools for 3D experiences**

Recommendation: 2.7 **Promote adherence to the principles of the London Charter for the Use of 3D Visualization in the Research and Communication of Cultural Heritage**

Recommendation: 2.8 **Develop solutions for improved search, identification, re-use and integration of 3D datasets by end users**

Recommendation: 2.9 **Provide solutions for effective rights management of 3D content**

Recommendation: 2.10 **Ensure access to 3D content through the European Digital Library**

Recommendation: 2.11 **Aim at non-textual, semantic documentation and processing of 3D content**

Group: 2.2 Specific RTD for site-based systems

There are many negative impacts on natural and cultural heritage sites, standing heritage structures and subsurface archaeological sites because of environmental, economic and social factors, in particular, global climate change and regional and cross-border infrastructural development. Enhanced or new ICT applications could help to monitor and limit damage of cultural heritage. In general, more effective cultural heritage management systems and integrated online availability of information can help administrators, planners and contractors to take well-informed decisions that reduce unfavourable impacts on the cultural environment as well as allow for working more cost-effectively.

The increasing need of monitoring, risk assessment and proactive damage prevention has made the capability to integrate, process, visualize and analyse data sources a matter of urgency. This requires considerable improvement in the access to, and interoperability of, relevant data sources. Such sources for enhanced heritage management systems could come from

- mobile, GPS handheld tools that are used in field surveys and archaeological excavation work;
- ground-based remote sensing, e.g., from in-situ sensor networks that provide spatially and temporally referenced streams of data;
- remote, satellite and aerial sensor data and imagery (e.g., hyperspectral sensors, InSAR and LIDAR technology).

Often a combination of data from remote sensors, in-situ sensor networks and mobile tools will be required for optimal survey and documentation work and decision-making in specific situations. The following recommendations address research priorities that are understood to present short- to medium-term challenges.

Recommendation: 2.12 Leverage capability of mobile devices for field data collection

Recommendation: 2.13 Develop highly effective, integrated ICT tools for rescue excavations

Recommendation: 2.14 Investigate the usefulness of sensor networks in CH monitoring

Recommendation: 2.15 Leverage GIS-based CH management through model-driven approaches

Recommendation: 2.16 Cultural heritage organizations should engage in the development of European spatial information and monitoring systems

Group: 2.3 RTD to empower the non-professional end user

The recommendations in this section address a range of systems, applications and content services for non-professional access to, and interaction with, cultural heritage content. The following areas are covered:

- User-created Web-based content and metadata,
- Virtual environments,
- Mobile location-based and context-aware services,
- Ambient intelligence environments, and
- Augmented Reality systems.

The recommendations are presented in this order and proceed from more short-term to longer-term research priorities.

Recommendation: 2.17 Investigate and examine appropriate approaches to user-created content and metadata

Recommendation: 2.18 Examine further the success factors for implementing 3D multi-user virtual environments

Recommendation: 2.19 Consider carefully the available opportunities for providing mobile, location-based and context-aware cultural heritage information services

Recommendation: 2.20 Exploit new generations of mobile devices' capability for interaction with 3D content and avatars

Recommendation: 2.21 Develop self-learning systems that allow for dynamic provision of content and guidance

Recommendation: 2.22 Explore further group-centric applications for shared cultural experiences

Recommendation: 2.23 Develop ambient intelligence environments in order to help standardize applications for visitor experiences and site management

Recommendation: 2.24 Further develop Augmented Reality systems for use outdoors at cultural heritage sites

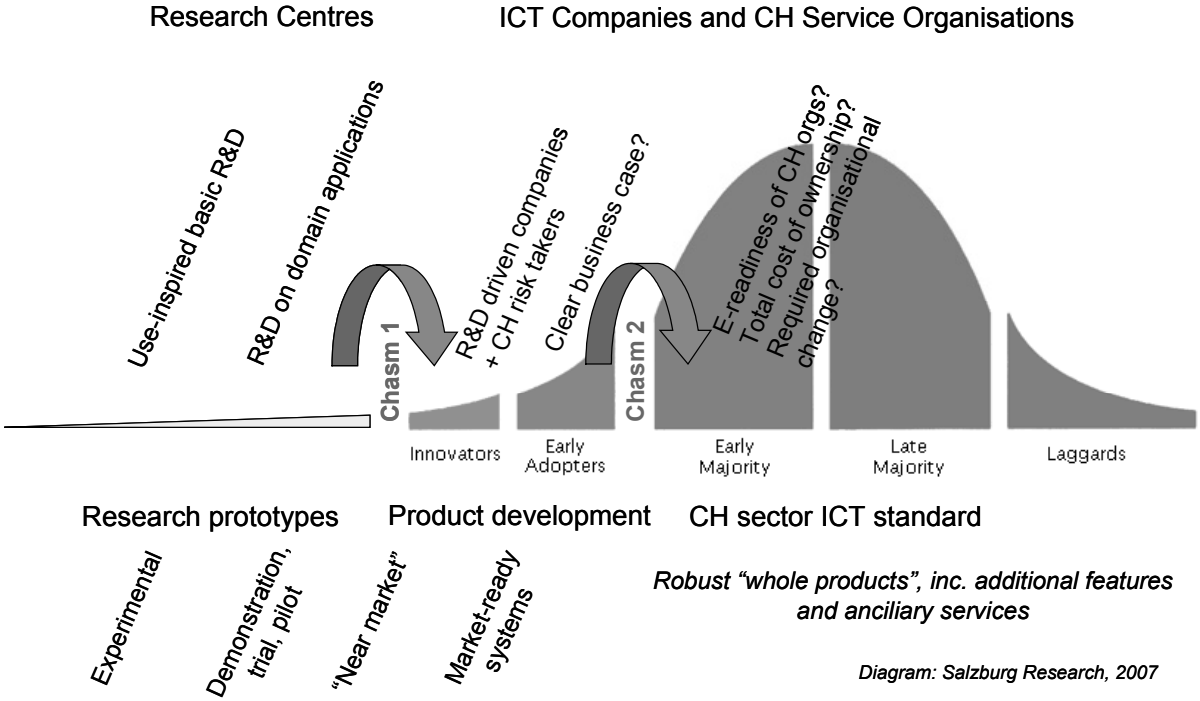
Recommendation: 2.25 Explore 'socially aware' and 'open world' interaction frameworks for Augmented Reality applications

Group: 3 Knowledge transfer, market development, and uptake

Valorization of the investment made in technological research and development for innovative ICT applications for specific sectors like cultural heritage is an important point on the agenda of policy-makers and funding bodies. The question is how prototypes and other research results, most of which originate from publicly funded projects, could be better exploited through the development of market-ready solutions. Furthermore, public agencies and

business associations will often ask what they could do to help make cultural heritage organizations more 'e-ready' and create business opportunities in this sector.

The Figure below depicts why an effective transfer of research results and wider adoption of innovative ICT solutions is difficult to achieve in the cultural heritage sector:



The Figure shows two 'chasms' in the diffusion of research results:

Chasm 1: This chasm concerns the transfer of 'near market' ICT prototypes to innovators and other early adopters in the CH sector. This transfer is hampered by the following situation: 1) There are only few research-driven companies that develop results of applied research into robust working solutions for the target market CH, and 2) this market is not characterized by strong incentives for seeking a competitive advantage as well as capability for the risk-taking that is required when adopting novel applications that have not so far proven their benefits. 3) For academic computer scientists the research issue is typically regarded as solved once the near market prototype has been produced and results published. Little career advantage is perceived in further investment of time.

Chasm 2: This chasm concerns the adoption at a late stage by many institutions in the CH sector of a more mature application, a whole product with additional features and ancillary services. The main problem here is that most CH sector institutions are small organizations that lack technical staff and support and are not able to cover the total cost of ownership for ICT applications from their operational budget. Many of them would be happy enough if they could afford a state-of-the-art Web site, have in place a better collection management system or enhance exhibitions with interactive displays. In order to overcome these chasms, novel business models for knowledge and technology transfer, market development, and support of cultural heritage institutions in the use of ICT applications are required. The following measures are suggested:

Recommendation: 3.1 **Leverage the knowledge base in progress, inhibitors and drivers in the digitization of tangible CH in 3D format**

Recommendation: 3.2 **Consolidate and disseminate knowledge in different approaches to 3D data capture**

Recommendation: 3.3 **Improve dissemination of critical knowledge about procedures to reduce digitization costs**

Recommendation: 3.4 **Tackle roadblocks in the exploitation of R&D results**

Recommendation: 3.5 **Investigate a wider range of potentially more effective models for the transfer of new knowledge and technologies from applied research and development**

Recommendation: 3.6 **Gain a better knowledge about the CH ICT market and companies that operate successful on this market**

Recommendation: 3.7 **Establish cultural heritage ICT expertise & service centres**

Recommendation: 3.8 **Promote sharing of lessons learned in business support models for SMEs and social enterprises in the CH sector**

Group: 4 Understanding socio-economic impacts of tangible cultural heritage and ICTs

Europe has a rich and diverse physical cultural heritage. Preserving and making use of this heritage for purposes such as cultural participation and learning, cultural tourism, regional development and cultural creative industries are of vital interest for Europe's economic competitiveness, job generation, urban and regional regeneration and citizens' quality of life (Lisbon Agenda).

The most obvious example is the tourism sector, which is worth hundreds of billions of euros in annual turnover in Europe and is one of the most important sectors of the European economy. Depending on the definition of the tourism sector, its contribution to the EU's GDP varies from 4% to ~11% and the number of people employed ranges from 7.3 million to 20.6 million, respectively. Estimates are that there are 1.171 million jobs in 'cultural tourism employment' in Europe (EU25), which is 15% of their figure for total employment in the tourism industry and 0.6% of the total employment.

The wider employment effect of cultural heritage museums and sites is thought to be considerable. For example, in France direct employment in 2002 of the cultural heritage sector of 44,880 produced related employment in the tourism sector of 176,800 (a ratio of 1:4) and further induced employment in other sectors of 260,830 (a ratio of 1:6). In addition, 41,700 people were employed in the conservation and maintenance of physical cultural heritage. Similar ratios (or 'multiplier effects') are given in a number of other studies. For example, in the UK the National Trust reports that it generates between five and nine additional full-time equivalent posts for every job for which it is responsible.

The Lisbon Agenda includes the goal to make the regions and cities of Europe more attractive places to work, live and invest and culture and cultural heritage are understood to be crucial for the specific character, identity and image of regions and towns and an important element of the quality of life of the residents. Consequently regions and towns not only invest in the infrastructure for cultural life (e.g., museums, places for performing arts, etc.), but tend to support cultural projects more actively.

What is hard to quantify, though, is the impact that individual investment choices have on the 'value added' by culture and cultural heritage. In part this is because the incremental effect on value in a country, region or town may be difficult to isolate and in part it is because the macro-level economic advantage may not be directly realized by those organizations which make the investment.

However, Europe spends many billions annually on the education of its citizens, a component of which is in their education as citizens engaged in their history and heritage. The interest and participation of citizens in culture and cultural heritage is considerable as shown by the important role of volunteers in the sector as well as straightforward on-site and online visitor numbers.

There is a promise that advanced ICT applications and digital content can further leverage the societal benefits of cultural heritage, but the question is how significant these benefits are. This means that wider strategic frameworks such as regional development and competitiveness must be considered, within which cultural heritage and ICTs can make a particular contribution.

Group: 4.1 Basic issues in a socio-economic research agenda for cultural heritage and ICTs

The following recommendations address some basic issues in a socio-economic research agenda for cultural heritage and ICT. These concern appropriate models and empirical data for policy making and decisions on investment in the preservation and promotion of cultural heritage, adoption of ICT applications in the heritage sector, and institutional capacity building.

Recommendation: 4.1 Fill the need for empirical models and data for policy- and decision-making on investments in cultural heritage

Recommendation: 4.2 Establish evidence of 'good value for money' of investments in tangible cultural heritage and ICTs

Recommendation: 4.3 Promote more studies that demonstrate benefits of implementing particular cultural heritage ICT applications

Recommendation: 4.4 Develop indicator-based models for regional and urban development strategies concerning cultural heritage

Recommendation: 4.5 Identify and address the need of education, training and continuing professional development in cultural heritage ICTs

Group: 4.2 Methods and tools for capturing and analysing the socio-economic impact of cultural heritage

The heritage value of a place or object, i.e., its specific historical, symbolic, spiritual, aesthetic and other aspects, is the major reason underlying its conservation as well as the basis for its economic and social benefits and impacts. From the economic point of view, the value of a cultural heritage asset lies in the benefits that can be derived from its direct and indirect use and, even, non-use values.

Direct use value of a heritage site or historic building can be captured comparatively easily, but indirect use values are difficult to evaluate. Furthermore, people derive value from having the option to visit a heritage place even if they never do ('non-use value'). Methodologies and instruments for capturing different benefits and impacts of tangible cultural heritage are therefore a particularly important field of research and development. Furthermore, standardization, identification of best practices and lessons learned, and guidance material are of high importance.

Research and training in this sphere should enhance the understanding of the heritage system and give heritage site managers a much clearer comprehension of how alternative choices of activity and investment can influence impact in economic, social and environmental terms. There also is a need for linking plans and activities for leveraging the impact of sites more fully into medium to longer term development strategies of regions and cities, e.g., sustainable development and quality of life or cultural cluster or/and cultural tourism strategies.

There are different methods for capturing the value people attach to cultural heritage places and features, which can be subdivided into market and non-market analyses.

Recommendation: 4.6 **Develop standardized and easy to use tools for market analysis of the economic impact of heritage sites**

Recommendation: 4.7 **Promote a wider usage of non-market valuation methods in the cultural heritage sector**

Recommendation: 4.8 **Develop tools for non-market valuation of cultural heritage ICT applications**

Recommendation: 4.9 **Provide systems and tools for cost-effective ICT-based data capture for valuation studies**

Recommendation: 4.10 **Aim at advances in techniques that allow for reducing the complexity and cost of heritage valuation studies**

Recommendation: 4.11 **Provide heritage impact analysis in support of policies that ensure a fair sharing of economic benefits from well-preserved and managed heritage sites**

Group: 4.2 Research challenges in the development of sustainable cultural tourism

Cultural tourism is seen as a particularly interesting segment of the tourism industry and a key factor for the economic development of many European cities and regions. It is expected that in the next few years the competition for visitors between cultural tourism destinations will become fierce. Newcomers and established destinations will need to be very inventive to stand out among the many competitors. The required innovation not only includes measures that allow for exploiting positive aspects of cultural tourism but also considers the possible negative impacts of tourism development, particularly at heritage places with limited tourist-carrying capacity.

Among the potentially positive aspects of cultural tourism development are the following: People increasingly look for authenticity and meaningful experiences, opportunities for self-development and personal fulfilment, and quality in tourism environments and offerings. Cultural heritage tourists tend to spend more money while on vacation and are more likely to be from an older age group, hence, the trend towards the 'aging society' works in favour of heritage destinations.

However, there are also many critical aspects of cultural tourism which regions and towns should consider when investing in the development of heritage sites: There is a rapid consumption of heritage places (e.g., by day-trip visitors) and return visits are unlikely. At the same time, heritage places may be 'mummified', i.e., imprisoned in their immutable uniqueness and stringent expectations of visitors that leave little room for renewal. Also the displacement of traditional economic and social functions through tourism infrastructure and the degradation of public spaces from crowds of visitors, increased levels of traffic and parking, thoughtless behaviour by visitors, etc. can be considerable. Indeed, local people will often face a situation where they must compete with tourists for space, local services and opportunities to enjoy their life.

The typical consumption patterns and potential negative impacts of heritage tourism make a proactive tourism management by regional and local authorities and site managers a necessity. The heritage site and the host community should be the most important stakeholders in cultural tourism development, and local authorities must understand that protecting the site and the quality of life of the local people are essential for sustaining tourism in the longer term.

A large part of tourism in Europe is motivated by having the opportunity to experience and enjoy cultural and natural heritage sites. Therefore, the sustainability of heritage sites in environmental, social and economic terms should be high on the agenda of policy-makers at all levels. While tourism is often seen to threaten heritage sites by unsustainable usage levels it also is important for their long-term viability. As the different purposes of heritage sites (preserve) and tourism organizations (exploit) will often be in conflict, mutual understanding, partnerships and cooperation for sustainability probably will be the best way to prepare the ground for acceptable tradeoffs and sustainable solutions.

Recommendation: 4.12 **Address the need for targeted research, guidelines and advice on sustainable tourism development**

Recommendation: 4.13 **Assess and consolidate the knowledge in models and indicators of sustainable tourism**

Recommendation: 4.14 **Assess and leverage the usefulness of the Tourist Area Life-Cycle Model and the concept of carrying capacity in the area of heritage tourism**

Recommendation: 4.15 **Expand the knowledge in, and applicability of, indicators of sustainable heritage tourism**

Recommendation: 4.16 **Support bottom-up approaches in documenting the impact of heritage tourism**

Group: 5 Integrated approaches for heritage sites and ICTs in the experience economy

There is a need to develop integrated approaches for heritage sites and ICTs that may allow for leveraging the socio-economic benefits of cultural heritage for regions and towns. One important framework for such approaches is the so called 'experience economy'. Historic towns and cultural heritage sites should be aware of the competition and develop an experiential positioning, i.e., define and create distinct experiential values for cultural tourists.

Because of the widespread borrowing of concepts that seem to be successful elsewhere, there is a considerable convergence in the strategies that regions and towns use in the development of their cultural assets. Instead of an innovative 'placemaking' that stimulates cultural creatives and attracts purposeful cultural tourists, the result is a growing number of rather sterile and inflexible cultural spaces. Typically these spaces reproduce stereotypic notions of culture and heritage and reinforce passive cultural consumption patterns. In order to stand out, regions and towns should use a distinctiveness strategy to create a unique position and brand on the cultural tourism market.

In developing a distinct, high-quality cultural tourism environment, regions and towns should combine in an integrated way several strategies. Section 11.7 illustrates the way in which historic towns must combine several development strategies in an integrated way. In the experience economy, regions and towns cannot count solely on the attraction value of built cultural heritage. Rather, an experiential positioning should be developed that also builds on other unique features and existing regional strengths. This is also important for fostering creativity and cooperation among regional stakeholders, retaining talented people, and attracting inward investment of new businesses.

ICTs and online media are only one component of strategic development among many, though it is clear that they can help regions and towns to gain competitive advantage in several ways. These are summarized in the following recommendations, with a focus on the particular challenges of communicating the experiential benefits of historic towns and sites. A number of ICT applications and online media are addressed that provide particular opportunities in the context of cultural tourism. As the Research Agenda concentrates on research needed to realize the potential of ICT support to the tasks and content of cultural heritage organizations and related stakeholders, applications such as general purpose marketing platforms, online booking, ticketing and purchasing are not addressed.

Recommendation: 5.1 **Consider the high challenge of communicating experiential benefits**

Recommendation: 5.2 **Make use of a new generation of dynamic Web sites and Web portal technology**

Recommendation: 5.3 **Involve local people and institutions in the communication of place-specific cultural contexts and experiences**

Recommendation: 5.4 **Seek to benefit from visitors' own images and stories and communities of interest**

Recommendation: 5.5 **Evaluate the effectiveness of cultural routes and electronic tour guides in attracting and retaining tourists**

Recommendation: 5.6 **Leverage the experiential value of on-site ICT applications for presentation and interaction**

Recommendation: 5.7 **Consider participation in research and development of ambient intelligence environments for historic towns and sites**

Recommendation: 5.8 **Make use of available and emerging applications for experiential positioning, planning and development**

Group: 6 The role of the European Union

Preserving and making use of the rich and diverse cultural heritage across Europe for purposes such as cultural learning and mutual understanding, cultural tourism, regional development and cultural creative industries are of vital interest for the European Union's economic competitiveness, job generation and citizens' quality of life (Lisbon Agenda).

ICT and digitization are providing new opportunities in the management and valorization of tangible cultural heritage such as monuments, sites and museums, as well as content that is held by archives and libraries. For example, traditional and new constituencies can be reached and served in ways that were unimaginable one or two decades ago.

The considerable investment by the European Commission in ICT projects related to cultural heritage has had a substantial influence in building a research community targeted specifically on ICT research needed to support cultural heritage. The results to date have been considerable, but as with many exercises in knowledge discovery, the 'more you find out, the more you realize you don't know'.

There is some way to go to realize the full potential of ICTs in support of the cultural heritage sector. In particular, this concerns effective tools for the use of the digitized and born-digital data and content, both for personalized search and research tools and for the authoring of relevant, meaningful and engaging interpretations and interactive cultural experiences.

To ensure that the emerging knowledge and experience is taken up and used by the sector will require research in these areas to be backed by a number of support actions and accompanying networking infrastructure. In view of the nature of the sector, which is made up mainly of 'social enterprises', it is certain that these measures will require public funding to make them effective.

In this Research Agenda we have explored a range of topics related to the inter-disciplinary research required to realize the potential benefits of ICTs in support of the many professional roles in cultural heritage. In this final section we conclude with some observations on the justifications for European Union-led support of the progression of this agenda. There are clear reasons for such support:

- Cultural heritage within the European Union does not recognize national boundaries. The links between the heritage of different states of the Union span migrations of ethnic groups, changing political boundaries, trade links, developments and spread of technologies, cultural influences and the spread of design styles, along with the inter-cultural influences and freedom of movement within the EU of today. It is clear that national investment in techniques appropriate to particular elements of heritage will have significance well beyond national boundaries. The fact is that benefits of such investment are unlikely (for example) to include the development of a purely commercial new industry sector which an individual nation might exploit through exporting skills. It is therefore appropriate as a European investment.
- The Cultural Heritage Sector and the organizations that support and use it have a less commercial, but socially valuable mission. Many of the enterprises involved (including many of the SMEs) would be better classed as 'social enterprises' than as 'profit-motivated', yet the sector as a whole is of very significant economic importance to Europe. If the sector is to grow healthily then investment is needed in the support infrastructure for these 'social enterprises'. Organizational development, technological infrastructure, access to specialized expertise, shared best practices and market intelligence are just some of the aspects that would benefit from a systematic, Europe-wide, support infrastructure.
- Individual national research initiatives seem to accept the 'purist' view that the most valued research should be unbridled by limitations imposed by consideration of usefulness. In part this appears to arise from the perceived

need to have national research capability evaluated as at the forefront of international levels – measured using the same underlying philosophy of what counts. In fact this tends to devalue the inter-disciplinarity that many claim to be rising in priority. The framework programmes of the EU have in general been rather better at valuing use-inspired basic research, possibly because European Union programmes are less about national advantage than about mutual benefit.

- One of the major barriers to integration of European digital cultural assets arises from the lack of widely used standards and relating to this the lack of sufficient appreciation of the implications of cultural diversity for ICT systems. These needs are reflected in the current lack of multi-lingual and multi-cultural thesauri, taxonomies and ontologies and in the multiplicity of national documentation standards in use. A Europe-led initiative is much better placed to ensure the definition and adoption of international standards (e.g., CIDOC-CRM).
- Individual member states tend to have national self-images which are less culturally diverse than the European Union taken as a whole. Promotion of a culturally diverse, but multi-culturally aware society is a healthy objective for the Commission, but many of the more challenging research topics relate to the difficulty of achieving ICTs capable of personalized multi-cultural responses to queries. Research in this area must be suitable for European support, and is actually considerably longer term.
- A rather more obvious and immediate reason for the topics raised here to be supported at European level is that only continued investment in research in these fields can enable organizations to deliver on the vision of the European Digital Library, both in the area of mass digitization of the full spectrum of cultural artefacts and their metadata and in providing appropriate access and exploitation of digital cultural assets.

Recommendation: 6.1 **We recommend that for the many reasons given in this document the European Union continues to co-fund both use-inspired basic research in ICTs to support potential cultural heritage applications and applied research to realize the potential in application areas that have demonstrated this potential**

2 Introduction

2.1 EPOCH's contribution to a Research Agenda for Applications of ICT to Cultural Heritage

This report presents the results of the research agenda definition activity of the EPOCH (Excellence in Processing Open Cultural Heritage) project. EPOCH is a Network of Excellence that has been funded under the European Union's Sixth Framework Programme, Priority 2, Information Society Technologies. The objective of the Network has been to integrate the previously fragmented efforts in research directed toward intelligent information and communication technologies (ICT) for tangible cultural heritage. The intended application fields of these technologies specifically are monuments, sites and museums.

The EPOCH Network of Excellence has a consortium of 95 university-based and other research centres, technology companies and consultancies, and public agencies and individual institutions responsible for cultural heritage along with a large number of affiliated organizations. Therefore the Network also has a role to play in the formation or strengthening of joint activities within the European Research Area (ERA) with respect to research, infrastructures, mobility of researchers, knowledge sharing and education that are of particular importance to ICT for cultural heritage.

The European Commission's Green Paper *The European Research Area: New Perspectives* of 4 April 2007 (EC 2007e) summarizes the ERA concept as encompassing "…three inter-related aspects: a European 'internal market' for research, where researchers, technology and knowledge can freely circulate; effective European-level coordination of national and regional research activities, programmes and policies; and initiatives implemented and funded at European level."

EPOCH already has contributed to these goals in a number of ways:

- Innovative tools and services have been made available: For example, the EPOCH Web service for creating 3D models, developed by the Computer Vision Group of the Katholieke Universiteit Leuven; Meshlab, a system for the processing and editing of unstructured 3D triangular meshes, developed by CNR-ISTI/Visual Computing Laboratory, Pisa; the AMA and MAD tools for mapping metadata schema into a CIDOC-CRM-compliant format (led by PIN and involving a number of other partners); the core of the virtual reality development environment, vhdPLUS, developed by MIRALab (Geneva) and VRlab (Lausanne);
- Knowledge has been shared and disseminated widely at major conferences and meetings of research groups (e.g., the VAST conferences);
- Contributions have been made on many occasions to consultations on research programmes at the European and national level;
- Members of the Network have hosted and trained graduates who received grants from CHIRON (Cultural Heritage Informatics Research Oriented Network), a Marie Curie Early Stage Researchers Training project;
- EPOCH's Research Agenda for the Applications of ICT to Cultural Heritage complements these activities through identifying and describing important topics and priorities for future research.

2.2 Why a research agenda?

The EPOCH activity in defining a common research agenda for the application of ICT to cultural heritage is understood as a support in giving direction to many ongoing but fragmented research and development efforts throughout Europe and beyond. Hence, an important aim of the activity is to stimulate the emergence of a better integrated layer of such effort within the European Research Area (ERA).

The principal benefits of a common research agenda on basic and applied R&D for cultural heritage ICT applications are that it can:

- provide cues for R&D investment decisions by funding agencies by identifying critical research strands and high-priority topics, current limitations and gaps, and ways to leverage R&D investments by coordinating research activities;
- be a useful tool to mobilize stakeholders and form project consortia to target identified key R&D challenges;
- provide the members of the ERA community with a longer-term sense of purpose and direction to research planning, independent of the short-term priorities of individual funding agencies;

- stimulate monitoring of progress along the way, and help to identify required related activities, such as provisions and measures for fostering the uptake and broader use of research by technology companies and cultural heritage organizations.
- In this way the existence of a common research agenda is expected also to foster a better cohesion of the communities involved, promote synergies among new initiatives and projects, yield more efficient spending of the available funding, and result in better and more sustainable ICT-based solutions.
- In this context also the importance of appropriate approaches of sharing results of R&D work must be noted. Among these approaches are Open Access to research data and publications, Open Source and freely licensed software for non-commercial use, as well as open Application Programming Interfaces for services that have been developed in research projects.
- The research agenda presented in this report primarily centres on short to longer-term R&D challenges in a number of research topics. Clearly, a research agenda is not a survey of current software for CH organizations that consider implementing certain ICT applications and would need an overview of available options and good advice on how to select the most appropriate application. PEOCH has undertaken work in this area and interested readers are referred to the EPOCH 'KnowHow' books.
- Museums and other CH organizations have a broad core mission (i.e., collect, manage, preserve, research and mediate knowledge) and, in addition, there are demands to forge collaborations with the tourism sector and cultural industries. In some EU countries museums have a specific mission to entertain. Therefore, EPOCH nourishes a holistic, interdisciplinary view of the role of all disciplines and professions that contribute to ensuring that the cultural heritage sector is an important element in the socio-economic development, lifelong learning, and quality of life in Europe.
- The Research Agenda does not nourish a 'technology-push' view of the potential dissemination of new ICT applications to the cultural heritage and related sectors (e.g., cultural tourism organizations, cultural and creative industries). The focus is on the middle ground between 'R&D players' push' and potential 'implementers' pull'. Indeed, there has been much past progress in prototypic applications that are of relevance to CH organizations but have yet to achieve their potential market penetration. Often a new technology has been proven to work in principle, yet needs to be developed into a marketable solution. In many other areas of ICT application, this journey from demonstrator to workable product may involve an order of magnitude more development and testing than the original demonstrator. Adoption is unlikely to happen rapidly of its own volition.

Therefore feasible approaches that allow for overcoming obstacles in the transfer of knowledge and technology to solution developers and providers in the CH sector are of critical importance. Furthermore, availability of the required skills to implement new applications into the organizational setting of cultural heritage institutions as well as the technical skills for maintaining the applications cannot be taken for granted.

2.3 Research topics and priorities for future research

The Research Agenda concentrates on research needed to realize the potential of ICT support to the tasks and work processes of CH organizations. The focus is ICT applications for handling CH data and circumstances, for example, involved in capturing and structuring primary data about CH or ICT-supported communication of the significance of a site, but not generic technologies such as payroll, point of sale or ticketing systems.

Furthermore regarding the many tasks and work processes of CH organizations the selection of the topics addressed in the Research Agenda largely corresponds to the strands of technological R&D and socio-economic research that have been present within EPOCH.

Possibly most important to note is that this does not include topics in the fields of conservation of material heritage and preservation and curation of digitized and born-digital cultural resources. The nearest that EPOCH has come to this area is in the tools to support migration of metadata and semantic enhancement of legacy sources. With respect to digital curation, which is closer to our focus points, readers are recommended to consult the research roadmap of the FP6-IST coordination action DigitalPreservationEurope (DPE 2007) and the study by the Archaeology Data Service (UK) on 'big data' from archaeological projects (ADS 2007).

In the Research Agenda activity a number of topics and priorities for future research have been identified which also include socio-economic impact evaluation and other issues. Criteria that have been taken into account in the selection of research topics and priorities comprise:

- Potential for new or enhanced technological capability: This means that work on the selected research topic would require some basic R&D in ICT or applied R&D for getting to a prototypic application. It should not be a topic in engineering and customizing already-available applications. Less emphasis is given to topics which involve technology transfer from other domains or the re-engineering or adaptation of existing technologies.
- Relevance for cultural heritage organizations and their constituencies: Here issues will be of particular interest that could be better addressed if new or enhanced ICT capability were available, e.g., cost reductions in the digitization of CH resources, enhanced Web-based access to 3D digital content such as virtual reconstructions of heritage sites for purposes of research and learning, and more effective monitoring of protected CH sites.
- Potential wider benefits for domains such as tourism, regional regeneration, cultural and creative industries, e.g., specific applications for enhanced location-based mobile services for CH routes or 'ambient intelligence' environments at CH sites.
- Therefore, the Research Agenda may help researchers and research sponsors to consider particularly valuable strands of research. It is also important to emphasize that many research topics will require a higher level of interdisciplinary research, which, in the case of applied R&D, should also involve more domain expertise (e.g., archaeologists, museum curators and other CH sector experts) as well as non-professional user-groups.
- Finally we want to emphasize that EPOCH's Research Agenda mission is not completed with this report. Rather, it is hoped that the topics and priorities for future research in cultural heritage ICT applications will be widely discussed and adopted in a process of concrete agenda-setting in research programmes and joint projects of research groups of EPOCH partners as well as the wider research communities. In particular, such programmes and projects would aim at developing technologies with new or enhanced capability for vital CH purposes and tasks.

2.4 Methods used in the development of the Research Agenda

The Research Agenda has been developed based on:
- Drafting and analysing the implications of a number of scenarios of how future ICT systems could allow for an enhanced or new way of working by practitioners in the cultural heritage and related sectors (the scenarios are included in chapter 5);
- Suggestions from four Research Agenda workshops, including comments from experts not directly involved in the project, and presentation and discussion sessions of events organized by EPOCH and other projects or institutions;
- Consultation of a number of available research roadmaps with varying thematic coverage, for example, DigiCULT Forum's rather broad 'The Future Digital Heritage Space' (Geser and Pereira 2004) or the ORION Research Roadmap (ORION – Object Rich Information Network 2003) on 3D applications for museums with archaeological collections, or, as a non-European example, the GIScience roadmap of the US-based University Consortium for Geographic Information Science (UCGIS 2002; McMaster and Usery 2004);
- Screening of the current state-of-the-art in R&D in fields that are relevant to EPOCH;
- For some suggested research topics context studies have been carried out to ensure their relevancy not only from the perspective of technological R&D, but also with respect to the needs of the CH sector as well as wider environmental, social and economic considerations;
- Electronic comment rounds with participations from within EPOCH and beyond has helped to further refine some of research topics and priorities of future research.

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Session at the IST Event 2006 Helsinki; the EPOCH Museum Focus Group or the Mediterranean Conference on Archaeological Tourism (Paestum, Italy); The Annual Event of the European Association of Historic Towns and Regions (EAHTR) 'Cultural Tourism – Economic Benefit or Loss of Identity?' in Dubrovnik in October 2006; the EU Presidency Conference on 'Why Digitize – Who Benefits?' in Helsinki in October 2006.

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3 Considerations on relevant areas, types and horizons of research for CH ICT applications

In the framing of a research agenda for cultural heritage and ICT a number of basic considerations have to be made. These include the definition of relevant areas of CH ICT applications and the business processes such applications should support, the required types and horizons of research, and considerations on the specificity of the ICT applications for cultural heritage tasks which may result from this research and technological development (RTD).

Moreover the fact that the research community in this field is not limited to RTD for ICT applications must be taken into account. The community also comprises researchers in cultural economics, arts & humanities, social studies of cultural participation, cultural administration, regional regeneration and many other relevant fields of research-based guidance of policy making and professional work in the cultural heritage sector.

With regard to the area of RTD for ICT applications, the concept of interdisciplinary use-inspired basic research is suggested as the most appropriate approach for targeting new and enhanced ICT capability while at the same time considering relevance for cultural heritage purposes and tasks. Hence, alongside basic and applied RTD there research is also needed for gaining an in-depth understanding of current as well as likely future CH operational and user situations.

Last but not least in this chapter, related requirements are also briefly addressed, such as effective approaches of sharing research results, opportunities for young researchers to specialize in CH ICT, and transfer of knowledge and technology for product development and implementation.

3.1 Definition of relevant areas of CH ICT

The Cultural Heritage (CH) Sector involves many different types of organization such as memory institutions (monuments, sites, museums, cultural archives, libraries, etc.), local authorities and other public sector custodians of heritage, voluntary sector organizations (e.g., preservation trusts, arts organizations, etc.), and organizations providing services involving cultural heritage venues (research organizations, tourism, education, etc.).

Many of the ICT uses of these organizations are generic to any enterprise – accounting functions, banking, payroll, invoicing, communications, etc. – and some will relate to generic business situations – point of sale, ticketing systems etc. This Research Agenda is not targeted at these generic systems, but at the ICT applications which relate only to *cultural heritage data and circumstances*; though, in some cases there are overlaps – notably in the use of systems with cultural heritage data, where the systems may be suitable for processing data from other sectors, or in the re-use of digital assets in secondary marketing.

If we take into account the full spectrum of CH data and circumstances (or 'business processes') the following areas could benefit from novel ICT applications:

- Data collection/recording – the capture of the primary data about cultural heritage;
- Organization, structuring, analysis, and interrogation – search and navigation of primary data to create cross-reference information, classification, indexes and knowledge;
- Cultural heritage research (e.g., humanities, local/regional/national/European history, etc.) where ICTs offer potential intelligent tools;
- Interpretation and communication – spanning from the interpretation of evidence in order to produce reconstructions of sites, through to producing explanations of the cultural significance of artefacts (e.g., contextualization, different perspectives, etc.);
- Preservation and archival of records and secondary data;
- CH site and resources management (e.g., monitoring and preservation);
- CH on-site and online visitors/users (e.g., requirements of researchers, professional, general public, etc.);
- CH exploitation/valorization and regional development agendas.

For most of these areas there are already ICT applications in use, which, however, are felt to have considerable limitations for exploiting the full benefits of ICT for key tasks and processes. Engineering work on the basis of current technology will often not help to overcome these limitations; rather, additional technological research is needed for enhanced and new applications.

3.2 A framework based on CH business processes

Recent discussions have seen an ongoing development of a framework or matrix for a research agenda that could inform current and future research and development of CH ICT. A major result of the discussion is that the most useful approach to providing a framework where the ICT research considered is clearly of direct importance to cultural heritage activities is to concentrate on the notion of 'business processes' within a number of areas of CH activity.

The framework in Figure 3.1 has proved a useful reference in considering questions such as the degree to which the research envisaged is actually part of generic ICT research in support of any applications or required only as a specific consequence of enabling ICT applications for cultural heritage.

Level	**Data sources**	**Process**	**Information-flow**			**Process**
Digital frontier:	Field recording Artefact digitization (2D, 3D, Dynamic)	Artefact Capture	↓	|	↑	Digital Artefact presentation
Asset processing:	– 3D Data (e.g., 3D artefacts (with documentation)) – 2D Data (e.g., images (with documentation)) – Dynamic data (e.g., video and audio content (with documentation))	Data transformation	↓	|	↑	Asset selection (e.g., index-based search)
Semantic processing:	– Collection documentation – Legacy metadata systems	Collection / linkage – metadata formation	↓	↔	↑	Research/search and interrogation; experience authorship
Underpinning systems						
	Trans-lingual systems					
	Data management (storage archive and retrieval, databases)					
	Web technologies					
	Graphics and interactive systems					

Figure 3.1: The discussion framework relating CH business processes to ICT layers

In order to develop a systematic structuring and coverage of technologies, of course, several relevant axes of research and development need to be taken into account. Furthermore, the structuring should cover the processes from underpinning infrastructure to upper application layers. Common infrastructure is likely to form a layer of functionality which can be assumed to be available to support computation / interaction in any cell via libraries with defined APIs or, less usefully, embedded code.

3.3 Types and horizons of research addressed in the Research Agenda

3.3.1 Types of R&D and their specificity to CH ICT

The table below gives an overview of types of research and development, with implied focus, approach and time horizon. In the Research Agenda mainly the first two types of basic and applied R&D are considered. The concept of "use-inspired basic research" and the need for a higher level of interdisciplinarity in the development of CH ICT will be discussed in separate sections below.

Research & development	Time horizon	Focus / approach
Basic R&D in ICT	5–10 years	Use-inspired basic research to generate and expand technological capability Aims to increase the understanding of basic research issues in ICT and, at the same time, allows the development of improved technology for purposes that are specific to CH Will often require also to draw on theories, methods and results of other disciplines (e.g., cognitive sciences, linguistics, humanities, …) and will potentially benefit other sectors by re-engineering cultural heritage solutions as a spin-off from addressing CH requirements
Applied R&D/research prototypes	3–5 years	A still higher degree of interdisciplinary work, taking into account the knowledge of experts in the field, such as archaeologists, curators, and educationalists In technical terms, can be expected to use open standards and modular approaches to ensure technical flexibility and integration, and reliable methods of testing and validation
Near market R&D / from prototypic applications to market-ready solutions	1–3 years	Demonstrate, pilot and test prototypic applications under real work conditions Make them effective for CH requirements e.g., usability, missing features Ensure interoperability and good integration with existing systems / tools Create a "whole product", i.e., with required ancillary tools and services
Applications that are used in CH practice	Current	Make applications "off the shelf" for CH purposes Collect, consolidate and disseminate critical procedural knowledge, e.g., on how to achieve cost reduction Ensure maintenance and required service level

Table 3.1: Types of research and development

Specificity of the R&D work to CH ICT

With respect to the specificity of the research and development work that is conducted for CH ICT we understand that:

- There will always be layers of generic technologies (and generic or basic technology research) that are unaffected by needs of specific domains such as Cultural Heritage.
- There will remain elements of the underpinning technological systems which need to take into account specific knowledge of CH in order to operate efficiently. For example, it is widely acknowledged that CH has particular needs with respect to 3D acquisition.
- The higher the level, the more likely the research challenges are specific to CH. For example, this will be the case in applications that mediate CH knowledge and experiences (e.g., multi-modal interaction with digital CH objects and environments).
- To ensure as high a specificity as possible on all three levels, the concept of CH use-inspired research is proposed (see below). At the highest level there is an element of role reversal – the field of computer science is advanced by addressing the needs of cultural heritage
- Of particular interest also is to understand the time horizons to which perceived research challenges of different specificity to CH ICT should be related.

3.3.2 Time horizons of different research challenges

Within the EPOCH Network of Excellence a larger part of the technological work has been centred on the development of a common infrastructure. This has been envisioned as an end-to-end 'pipeline' of tools which support the handling of cultural heritage data from recording (e.g., during excavations), to analysis and interpretation, through to the publication of research results and exhibition of, and end-user interaction with, digital cultural content.

Research work has comprised defining the architecture and components of such a common infrastructure, evaluating existing and emerging new tools, and identifying or defining required standards for interfaces, data formats and exchange protocols for interoperable tools. For example, this included issues in 2D/3D artefact representation and metadata encoding for semantic information about aspects of the artefact based upon a common ontology, which EPOCH proposes to base upon CIDOC-CRM. Also, so-called NEWTONs (NEW TOols Needed) have been identified and a number of them developed in short-term smaller projects. examples are the UPGRADE software suite, which is being developed as a NEWTON, for the integration and fusion of acoustical, optical and platform navigation data in underwater archaeology, and the AMA tool for semi-automated mapping of national or de-facto international CH metadata and management standards to CIDOC-CRM.

In contrast to the work on a common infrastructure, the Research Agenda has a horizon that extends several years into the future, and aims to identify opportunities for developing ICT applications that are emerging today, but the potential of which will be fully realizable only in some years to come.

Below we distinguish three time horizons which present different R&D challenges. Most of the challenges addressed in the Research Agenda are in the time horizon medium to longer-term (ca. 2015), since the contents are expected to take some time to fully disseminate into the community.

Short-term research challenges – 2010

The first horizon, 2010, is about shortcomings in existing ICT applications for the domain of tangible cultural heritage that are in a prototype stage. These will often be shortcomings in applicability and resilience to special cases, in interoperability and challenges in the effective deployment of applications, but the solutions can already be envisaged given further development. Hence, such applications need a great deal of additional technical development to be able to provide the expected benefits to CH institutions and their users.

Medium to longer-term technical challenges – Horizon 2015

The second horizon we understand to comprise research challenges that arise from missing technological capabilities and/or as shortcomings in data standards, exchange protocols and interfaces which are not sufficiently mature. Some bottlenecks may be addressed and removed by 2010 based on existing technologies and methods; however, there will certainly remain considerable barriers until 2015 due to unsolved problems or technological capacity which is not yet available. Examples in this time-frame probably include seamless transition from scanned digitizations to reconstructed objects, including descriptions and semantics.

In the period up to 2015 we would expect targeted research and experimentation to achieve breakthroughs in one or more underlying generic technologies to remove the existing barriers. However, from the perspective of 2008, judging which research issues are likely to remain challenges must be largely speculative and relate more to the perception that a problem is 'hard'. A breakthrough could, of course, occur at any time.

Often this perception is due to the fact that there are co-dependencies of technologies, i.e., different technologies would need to evolve and come together to allow for a real breakthrough. Multilingual systems capable of semantic analysis in the cultural heritage domain can confidently expect to be one such area of ongoing challenge; 'open world' interaction with historic characters in an Augmented Reality environment also raises challenges across many technologies and is most likely to be part of a 'grand challenge' in CH ICT environments for some time to come.

'Grand challenges' – beyond 2015

In the last horizon we place 'grand challenges' – visionary goals of research that are not obviously possible, but which hold the potential for significant advances in knowledge and technological capabilities. However, incremental progress in research and development alone would not succeed as breakthroughs in several underlying technologies may be required. Major investments and long-term inter-disciplinary collaboration would be needed.

Inclusion of a research horizon that extends beyond 2013 may seem to be over-ambitious; however, we see the need for challenging the research community to explore new avenues of research. Currently, to formulate and foster research on a couple of 'grand challenges' may well be the right stimulus to removing existing bottlenecks and barriers within the next ten years, and considerably advance towards the next generation of cultural heritage ICT. One such initiative, named 'Bringing the Past to Life for the Citizen', has been proposed by David Arnold et al. and accepted in the framework of the Grand Challenges in Computing Research, organized by the UK Computing Research Committee – a joint expert group of the British Computer Society, the IET and the UK Conference of Professors and Heads of Computing.

It is understood that a 'grand challenge' in cultural heritage ICT, e.g., a large Augmented Reality environment at a CH site in which people can experience time-travel and interact with historic characters, will need a strong multi-disciplinary collaboration involving experts from different humanities (e.g., with respect to historical behaviours, language, architecture, etc.). A good grand challenge also informs shorter-term research which leads in the direction of the integrated solution. Such intermediate challenges are commonly described as 'foothills' projects.

It may also be worthwhile to consider 'grand challenges' in cultural heritage that are not of a technological nature. There are critical long-term issues in the management, communication and valorization of CH that could be addressed by a competition for completely novel approaches, in the preservation of intangible heritage, the mediation of cultural knowledge to new generations or the democratization of heritage through user-created content, for instance.

Considering the incubation time of IT innovations

A research horizon that extends beyond 2013, i.e., the time-frame of the 7th Framework Programme, also seems to be required to take into account the considerable incubation times of innovations in the area of ICT. Detailed studies on such incubation times have been conducted by the Computer Science and Telecommunications Board of the US National Research Council of the National Academy of Sciences (NRC-CSTB 2003). They show that many of the technologies that represent the basis of the current ICT industries needed 10–15 years from the first basic research to commercial introduction and exploitation. These include, among others, Reduced Instruction Set Computer (RISC) processors, parallel computing, relational and parallel databases, client/server computing, LANs, Internet, portable communication, computer graphics, and speech recognition.

The studies illustrate the complex interplay of university research and industry RTD, some of the concurrent, mutually reinforcing advances in multiple subfields and, most importantly, "…the long, unpredictable incubation period – requiring steady work and funding – between initial exploration and commercial deployment". This requires CH ICT research teams to watch out for and incorporate such mutually reinforcing advances in different areas of research and development. However, they will also need to put particular emphasis on inter-disciplinary collaborations that are sensitive to the particular needs in cultural heritage.

3.4 Use-inspired basic research – "Pasteur's Quadrant" and CH ICT research

Technology-centred research work in fields such as ICTs for Cultural Heritage tends to comprise a variety of research perspectives. In some areas basic, new computer science results must be developed specifically to address challenges which are unique to cultural heritage. In other areas the best of generic computer science research results must be applied to cultural heritage situations, potentially creating novel working methods for Cultural Heritage professionals. Such a range of situations can be understood neither as purely basic research in ICTs nor as a field of purely applied research. The research conducted is a mixture of basic ICT research targeted at enabling ICTs to solve specific problems with ICT applications.

EPOCH promotes a higher degree of inter-disciplinary use-inspired basic research. Such research increases the understanding of basic research issues in ICT and, at the same time, allows the development of improved technology for purposes that are specific to CH. The research aims at generating and expanding capability in generic ICT and considers CH requirements and data as a particular demanding field of testing assumptions, concepts, and ICT research prototypes.

Use-inspired basic research has been promoted in many ways in recent years as a means of ensuring that publicly funded research is firmly based on providing solutions that have exploitation potential. Donald Stokes' book "Pasteur's Quadrant: Basic Science and Technological Innovation" (1997) provides a framework to set the

different types of research in context. Stokes analyses the relationships and his evaluation merits more detailed discussion from the viewpoint of cultural heritage ICT research.

In "Pasteur's Quadrant" Stokes suggests abandoning the dichotomy between basic research and applied research and reconsidering the notion that "basic research" is the prime motor of scientific development and longer-term societal progress. In the United States, this notion of basic research was stressed by the extremely influential federal report "Sciences, the Endless Frontier" which was released in July 1945 by Vannevar Bush in his role as President Franklin Roosevelt's director of the Office of Scientific Research and Development.

The emphasis on basic research was informed by the notion that this type of research is the starting point of a linear progress from basic to applied research and from applied research to market-orientated development of solutions. Moreover, the idea was that basic research should receive a larger part of public funding because it may not be able to ensure adequate levels of funding in the marketplace.

Stokes argued that scientific research should not be conceptualized as a linear progress and introduced four quadrants of research:

Research inspired by:		**Considerations of Use?**	
		No	**Yes**
Quest for fundamental understanding?	**Yes**	Pure Basic Research (Bohr)	Use-inspired basic research (Pasteur)
	No		Pure Applied Research (Edison)

Figure 3.2: Stokes' Quadrant Model of Scientific Research (after Stokes, 1997, p.73)

- In the first quadrant he placed pure basic research which is understood to be inspired by the quest for knowledge but not by potential use. A paradigmatic example for this type of research is the physicist Niels Bohr who worked on a model of the atom.
- In contrast, the diametrically-opposite, second quadrant is reserved for pure applied research which is conducted to develop practical solutions and marketable products. Stokes example for this type of research is Thomas Edison and his work on electric lighting, sound recording and many other marketable, practical innovations.
- A third quadrant contains scientific work that is neither overtly theoretical nor directed at products. This work concentrates on the exploration of particular phenomena or the development of a taxonomy or other classificatory work. Rather than advance scientific knowledge or develop market-orientated solutions, the focus is more on formalising existing knowledge (e.g., domain ontologies) or academic practices (e.g., handbooks or guidelines). There is a lot of such research in Cultural Heritage and though Stokes left this quadrant unlabelled, he typified it by citing Charles Darwin's work in the classification of species here.
- The final fourth quadrant is reserved for use-inspired basic science. This is understood to have potential practical utility, but researchers who conduct such research do not lose sight of the goal of advancing scientific understanding. The paradigmatic example here is the work of Louis Pasteur. Stokes suggested that "Pasteur's quadrant" should receive most of the interest in national research policies and public funding, providing a combination of advancing knowledge and potential exploitation and return on investment. In this quadrant the delay between basic research and deployed solutions remains significant.

The notion of use-inspired research has significant implications for how scholars conceive of research which may face some tensions with current academic research cultures. In fact, if researchers concentrate on basic research they will usually do so within the confines of specific "pure" scientific disciplines that have their list of research priorities and established review and reward mechanisms. These priorities and rewards do not particularly foster considering practical, societal and policy-related considerations. Medicine as a field of research is probably

an exception – almost all research in this field would be classified in Pasteur's Quadrant, but is nevertheless viewed as basic research even in the linear spectrum which has been perpetuated under the Vannevar bush model.

Typically research which can be located in Bohr's quadrant has received the highest prestige in peer assessment of the quality of research. Given that exercises in assessing quality often purport to be based on assessment of novelty, rigour and impact, this might be considered an odd result, but there is no doubt that such attitudes have a material impact on the research which is valued and hence on the behaviour and careers of professional researchers. In this context, attempts to become more "use-inspired" may be considered to be misguided, despite the obvious link between research in Pasteur's Quadrant and some degree of intended usefulness of the results.

For example, in EPOCH's first "State of the Union" (Niccolucci, Geser and Varricchio 2006, 39) survey one researcher who addressed university research assessment criteria in the UK reported that

> "it would be hard to place 'Intelligent heritage' in the Research Assessment Exercise (RAE) and hard to persuade practitioners that they ought to be associated with it. In the 2000 RAE, heritage policy and research was specifically excluded from the RAE as being neither archaeology nor management, nor computing science, nor politics. In simple terms, anyone caught doing 'intelligent heritage', heritage policy or applied computing is likely to be sidelined or dismissed in order to enhance an institutional response to RAE." (William Kilbride, Archaeology Data Service).

Hence, there is a need to consider more deeply the values that prevent CH ICT becoming a more important interdisciplinary field of research.

In fact, in this Research Agenda there are aspects which can be considered as lying in each of the four quadrants of Stokes' diagram. In ICT, basic research can be targeted at underlying theory or indeed, in Stokes' quadrants, research aimed at solutions which are independent of specific applications. Generic technologies, which are mentioned in various places here, would fit this later definition of basic research.

The majority of the basic ICT research topics would fit in Pasteur's Quadrant, including all of the research targeted at intelligent tools. The argument in favour of conducting research in this quadrant is that *different* basic research is undertaken with the limits on available resources. Whilst Kilbride's perceptions of the potential treatment of such research in the UK's Research Assessment exercise may have some truth in it, this would reflect some shortcomings of the exercise rather than the rigour, novelty or impact of the research. The academic argument favouring Bohr's quadrant is that the basic research is not sullied by potential distortion to known objectives, possibly not the personal objectives of the researcher, were they to be given free license to pursue any topic.

There are also serious motivations for research in Edison's Quadrant. Often this may be targeted at applying pure basic research results (Bohr's Quadrant) at applications in Cultural Heritage. Of particular significance is the need to prove that the generic results work effectively with the data arising in significant practical situations, which would typically exhibit special cases and data volumes which often may not have been tested in the original basic research.

Stokes states that the quadrant that is not labelled should not be thought of as "empty", but in his view it includes research that "systematically explores particular phenomena without having in view either general explanatory objectives or any applied use to which the result may be put." Stokes particularly mentions research into taxonomies and there are other areas where systematic classification and analysis is needed in this agenda. For example the systematic analysis of architectural design styles is required as background analysis to support the widespread adoption of the grammar-based procedural modelling (see section 6.6.1). These do not in general add to the basic research results which prove the viability of the approach but they turn a prototype application (grounded on basic research - use-inspired or not) to a viable tool. In many ways research addressing the commonalities of different requirements in order to define best practice and standards also fit into the unlabelled quadrant as standards are intended to be useful in many different applications contexts.

3.5 Interdisciplinary research: Incorporating contributions by the humanities

Research and development in ICT for Cultural Heritage requires a high degree of interdisciplinary collaboration among computer science disciplines as well as with researchers and practitioners in heritage studies and management, archaeology and other humanities.

It is understood that such collaboration is not easy to establish due to the considerable differences of goals, tasks and approaches. For example, Neil Silberman with respect to the objective of standardising and integrating

processes of data capture, management and sharing across the CH sector argues that such a goal has to take into account the wide variety of theoretical orientations and approaches within the historiographical disciplines:

> "Alongside the traditional art-historical and culture-historical approaches to material culture (i.e., identifying and dating sequences of styles, artefacts, architecture, and larger arrangements of specific past cultures), are the anthropological approaches that seek cross-cultural typologies of the behaviour represented in the material remains. At the same time, processualists create dynamic models of ancient systems to test hypotheses about the mechanics of ancient societies. Structuralist and post-processual scholars, for their part, collect evidence to decode and deconstruct the unspoken 'texts' that the material culture of every period is believed to express. Each of these main intellectual streams represents a distinctive methodology of study, with particular preferences for certain kinds of data and distinctive and differing criteria for documenting and analyzing the evidence." (Silberman 2007, 98-99)

He points out that the present fragmentation and inconsistency of information sources is to a considerable degree the result of distinct and long-established disciplinary epistemologies, which determine how the scholars in the specialised sub-fields and methodological traditions conceive of objects of study and make them see different types of data as significant. Yet, Silberman admits that the effort to establish interoperable tools for data collection, management and analysis "can be the first step in creating innovative, new multidisciplinary forms of historiography. Widening access to new classes of networked data will encourage a deeper consideration of their commonalities and contrasts."

This of course is not to be understood as a CH technology push model of overcoming barriers to inter- or multidisciplinary collaboration in CH ICT. Rather, since the 1990s ever more humanities research teams and institutes themselves have become active in what is called "humanities computing" or "digital humanities". Indeed, the development and use of Web-based tools, virtual research environments and digital collections by humanities scholars has grown considerably (cf. McCarty 2005; Rydberg-Cox 2006; Schreibman et al. 2004) This has not helped that much in overcoming the considerable fragmentation in humanities scholarship, but, the emphasis placed on cooperative research work has stimulated a questioning of the traditional "lone scholar"-type research as well as a greater acceptance of scholarly publication in digital formats.

Notably, "integrative" technologies such as web-based mapping and GIS applications are playing an important role in driving collaborative approaches. Some well-known examples in this field are the Electronic Cultural Atlas Initiative and TimeMap applications (http://www.ecai.org), the ArchAtlas project (http://www.archatlas.org), which centres on spatial processes in prehistoric and early historic times, and the Pleiades project (http://pleiades.stoa.org) which focuses on ancient geography. Another case in point is the European Historical GIS Initiative (http://www.hgis.org.uk) which is promoted by research groups from the Lancaster University (UK), the Queens University Belfast (UK), the Institute of European History, Mainz (Germany) and the Purdue University Indianapolis (USA).

In recent years there also has been a much stronger integration of academic groups and associations in the humanities. Most notably, the Association for Computers in the Humanities (ACH) and the Association for Literary and Linguistic Computing (ALLC) have formed the Alliance of Digital Humanities Organizations (ADHO; http://www.digitalhumanities.org), which since 2007 also includes the Society for Digital Humanities / Société pour l'étude des médias interactifs (SDH-SEMI). The Alliance runs the Digital Humanities Conference and their Digital Humanities Quarterly is a new peer-reviewed and open-access electronic journal (the first issue was published in spring 2007).

In organizational terms, humanities computing has been institutionalised in many different ways (cf. the overview of McCarty and Kirschenbaum 2003), though, exemplary role models are academic units that provide a mix of research and development projects, teaching and collegial service. Furthermore, a number of community exchange platforms have emerged such as Digital Arts & Humanities in the UK that has been developed by the AHRC ICT Methods Network and hosted by King's College London (http://www.arts-humanities.net).

In a wider perspective it is important to note that the expert group who advised the European Commission on the positioning of humanities research in the 7th Framework Programme concluded that the humanities can add a much required focus on the cultural and historical dimensions of European integration and current developments in society, including all the challenges raised by the Lisbon Agenda. Though, the expert group found that humanities scholarship is a resource that is underutilised with respect to the Lisbon Agenda and other policy agendas. (EC 2007f)

Contributions from, and interdisciplinary work with, researchers from the humanities particularly will be beneficial with respect to several issues in cultural heritage. Most critical maybe are issues in the preservation of intangible heritage, that by the terms of the UNESCO Convention on the Safeguarding of the Intangible Cultural Heritage, is defined as "the practices, representations, expressions, knowledge, skills — as well as the instruments, objects, artefacts and cultural spaces associated therewith — that communities, groups and, in some cases, individuals recognize as part of their cultural heritage." (UNESCO 2003)

As the text of the Convention suggests by the explicit mention of the relationship of intangible ideas and traditions to material objects, artefacts, and cultural spaces, tangible and intangible heritage are not to be understood as completely separate categories, rather, physical and ideational aspects are becoming more closely intertwined in heritage research and protection. Considering that the humanities, among others, comprise studies in language and literature (both modern and classical), historic studies, cultural anthropology, comparative religion and ethics, cultural geography and studies of the human environment, their contribution in bringing research in tangible and intangible heritage much closer together should be substantial.

Important related themes are cultural memory, identity and diversity in Europe and beyond. For example, research within CLIOHRES.net, a Network of Excellence in the 6th Framework Programme, "aims at achieving and disseminating greater understanding of both the actual histories and the self-representations of the past current in Europe today, highlighting both diversities and connections and explaining the context of their development". (http://www.cliohres.net)

HUMAN PLUS, the Archipelago of the Humanistic Thematic Networks, is a cooperation of 20 Erasmus-Socrates Thematic Networks that deal with different areas and topics of the humanistic arts and sciences (http://www.archhumannets.net). Several of these Networks are of interest when discussing and promoting cultural heritage, for instance, the ACUME Network investigates cultural memory in European countries. Their fields of research are Places and Memory, Cultural Amnesia, Bearing Witness, Oral and Written History and Foundation Texts and Mythology. (Archipelago 2006, 4-5; http://www2.lingue.unibo.it/acume)

Indeed, it will be important to pay much more attention to cultural discourses and representations, narratives, symbols, metaphors and visualizations that accompany and articulate contemporary socio-cultural phenomena. This will include, among other phenomena, the use of tangible and intangible heritage by ethnic groups to define their cultural identity; increased cultural sensitivity, which requires much more guidance with respect to CH interpretation; the "localization" of products of the cultural and creative industries or cultural tourism offerings; the changing role of CH in the developed countries from traditional definitions of "national patrimony" to "personal" meanings of heritage.

3.6 Research needed for understanding CH operational and user situations

Besides the need to forge closer collaborations with humanities scholars, novel approaches are also needed to better understand CH operational and user situations that involve ICT applications. There is often a predominance of the 'hard' view of system science – the view that for a perceived need tools can be devised which will satisfy the requirement and hence solve the problem. However, it is demonstrably true that the adoption of technological solutions rarely if ever follows the designed path and their significance needs constant re-interpretation as they become deployed within wider demands and contexts of CH tasks and requirements of end-user experiences.

Therefore, the Research Agenda also emphasizes the importance of components of research on particular CH operational situations as well as the ways end users make or do not make use of novel applications in certain contexts. Some examples of such research are:

- *Capability of CH institutions:* Many CH institutions, particularly the smaller ones, will need to have a certain degree of 'e-readiness' to consider adopting certain technologies in the first place, e.g., with respect to ICT-affinity, available budgets, technical skills, etc.
- *Effective development of sectoral capacity:* Competence profiles in the CH sector comprise different types and levels of 'ICT literacy' that is required for effective deployment of ICT, e.g., digitization, enhanced online access, onsite interactive installations, etc. New applications of ICT often will need to be accompanied by appropriate (re-)training and support of practitioners. For example, it may be necessary to overcome current misconceptions of 3D technologies and lack of use by archaeologists. In a presentation at the EPOCH workshop on syllabuses for Cultural Informatics, Julian Richards quoted a survey that put ICT skills as the topic which archaeologists felt was most under-represented in their courses.

- *Organizational change:* New systems and tools will often impact on established 'traditional' ways of working in CH situations, and hence will face considerable organizational barriers to adoption and resistance by staff if developed without a good understanding of the systemic nature of practices, circumstances and contexts in the application domain.
- *CH asset management:* There are many issues in ICT-supported processes that relate to the proper handling and protection of IPR, copyrights, provenance and other descriptive information, and wider concerns about the authority of CH institutions in the digital realm. For example, many CH institutions worry about easy illegitimate re-use of their digital content or do not wish their content and authoritative interpretation to be mixed with or presented alongside other, possibly offensive, material.
- *Usability and user experience research:* This includes tool usability for CH tasks (professionals) and other uses (site visit, education, etc.) and factors that promote or impede the experience of being supported in a work situation, in learning about a site or museum objects, and enjoying and sharing ideas and experiences with others. In the development of future applications, end users must be involved much more and in different ways than is the case in current R&D practice. For example, in the development of 'ambient intelligence' systems, i.e., environments of distributed, context-aware computing and novel types of user interface, approaches of 'experience prototyping' will need to be employed in addition to traditional methods of requirements engineering and usability studies.

In fact, expertise in human, social, organizational and economic matters will often be decisive if proposed new technologies shall have a chance to find their way into the CH sector. If they are adopted, the professionals working in certain areas must have ownership of the responsible use of technologies. In this case they must often find the right balance between different goals, for example, the conservation of fragile cultural heritage may conflict with the wish to provide better access for the citizen, or presenting diversity and richness of CH perspectives in contrast to choosing to present and interpret from limited perspectives in order to present clearer messages.

3.7 Appropriate approaches of sharing results of R&D

Initiatives to promote progress in research and development for applications of ICT to cultural heritage will also need to consider the most effective approaches of disseminating and sharing results of the research work. In general, the research communities in CH ICT show a high level of openness with respect to how research results are made available. Yet, considering the current debate on Open Access and Open Educational Content (Geser, 2007) it may be appropriate also to address this topic and give some recommendations.

Reliable, affordable and permanent access to research results is an important enabler of the dissemination of, and further progress in, scientific knowledge. Ideally it should be possible to seamlessly navigate, consult and make use of interlinked scientific information from raw data to publications. Furthermore, there would be research tools that allow fresh analysis and utilization of data beyond what the originators had in mind. Today's online libraries of publications and repositories of scientific databases are a first step towards this vision.

Recently, steps also have been taken with respect to the issue that data and publications resulting from publicly-funded research are often not readily available. This issue has been addressed in several declarations such as the Berlin Declaration on Open Access to Knowledge in the Sciences and Humanities (2003) and the OECD Declaration on Access to Research Data from Public Funding (2004). In the Communication of the European Commission on 'i2010: Digital Libraries' (EC 2005c) and 'Scientific information in the digital age: access, dissemination and preservation' (EC 2007a) the need of easy access to research results has been emphasized. This has been reinforced in the consultation on the European Commission's Green Paper *The European Research Area: New Perspectives* (EC 2007e). With respect to the priority 'knowledge sharing' most replies called for raw data and publications resulting from publicly-funded research to be made more readily accessible.

As a matter of fact, in many disciplines funded projects aggregate large amounts of datasets, but only a smaller fraction of processed data (about 5–10%) finds its way into publications, which is a tremendous waste of effort. The reasons for this waste are manifold and include researchers tending to see the datasets as their property, there seems to be little professional reward for 'raw data', and projects face limitations to effectively curate and make available large datasets. On the other hand, it has been shown that articles associated with publicly available data have a citation impact advantage (Piwowar et al. 2007).

More readily available interlinked collections of datasets would not only allow for a better valorization of the initial investment through further research by others, but such collections can also provide useful material for

teaching, exercises and other coursework for students. It is thus recommended that datasets be provided to existing data curation and access centres or support the creation of data repositories in fields where there may be a lack thereof.

With respect to research publications, researchers who want to make sure that their work can be accessed freely in due course will consider a journal that grants open access to their work some months, preferably no more than six, after the initial publication of the otherwise subscription-controlled content. Another option is to consider a journal that offers immediate open access based on the 'author pays' model. Regular use should also be made of the allowance of many journals, after a certain delay period, to self-archive the work in an openly accessible repository, e.g., an institutional or discipline-specific electronic repository.

Besides more readily-accessible research data and publications, there is also the question of how to make software from R&D projects available. It is widely understood that Open Source software is a particularly suitable way of allowing the re-use of software among developer communities. To provide but one example, in the field of 3D acquisition, data editing and rendering EPOCH researchers promote OpenSG, which is an open source, portable scenegraph system to create real-time graphics programmes. Moreover, Open Source code allows for extensible and potentially more sustainable CH ICT applications. Also it is understood as a requirement for transparency of research models and interpretations, e.g., of virtual reconstructions of cultural heritage (Forte and Pescarin 2005; Pescarin 2007).

3.8 Leverage in CH ICT relevant education

An exploratory EPOCH survey on the offer of CH ICT-related courses at universities throughout Europe (Niccolucci 2006b) suggests that in many European countries there is a need for more such courses, and in most countries for more programmes that allow for a specialization in this field. At least one relevant course is often present in studies such as archaeology, museology, cultural heritage management and others.

The survey results also suggest that there is a considerable lack of CH ICT-related courses in computer science, information systems and other technological departments. Certainly there are quite a number of courses in generally relevant subjects, but the link to CH-related purposes is not necessarily present. It is more likely if there are lecturers from research groups who have experience and examples from their own R&D work in CH ICT. The University of the Aegean (Greece) with their Department of Cultural Technology and Communication is a rare example of a university offering a full curriculum from the undergraduate level, to an M.Sc. in Cultural Informatics and on to a doctorate in this field.

Considering the importance of the 'Bologna Process', which aims to create a European Higher Education Area by 2010, European Masters degree programmes with a focus on CH ICT would be particularly welcome. One example of such a programme is 'European Heritage, Digital Media and the Information Society' (EuroMACHS), which in 2006 started running at the universities of Coimbra (Portugal), Cologne (Germany), Turku (Finland) and Lecce (Italy). This topic was also covered at the EPOCH workshop on Cultural Informatics (Hermon, 2008).

3.9 From research prototypes to solutions that work in practice

While the Research Agenda centres on interdisciplinary use-inspired basic and applied R&D, there is also the critical issue of how research prototypes and other research results, most of which originate from publicly funded projects, could be better exploited in actual development of new or enhanced CH ICT solutions. Experiences from many projects show that an effective transfer of research results to organizations that develop, implement and service solutions for CH purposes is difficult to achieve.

However, as an effective transfer and uptake is crucial for realizing the values of the investment in dedicated research on ICT applications for the CH sector, it is felt that research groups and centres that are active in this field have a particular responsibility to consider strategies that might leverage the transfer and adoption of their research results. In other words, the responsibility of researchers must not necessarily end with publishing results and making research prototypes (in most cases software) available to others outside the original research group.

The questions of why an effective transfer of research results is difficult to achieve, and what approaches could potentially address the issue, are outlined in Chapter 10.

3.10 Summary on important basic components of research for cultural heritage ICT applications

The discussion in this chapter of basic components of research for cultural heritage ICT applications can be summarized in the following recommendations.

Promote a higher level of use-inspired basic research in ICT that may pave the way to new or enhanced applications for purposes that are specific to cultural heritage

The Research Agenda promotes a higher degree of use-inspired basic research as this can increase the understanding of basic research issues in ICT and, at the same time, allow the development of new or enhanced applications for purposes that are specific to CH. Such research considers the CH sector with its specific tasks and requirements as a particularly demanding field for testing assumptions, concepts and prototypes. Thus the R&D results will also have the potential to lead to enhanced or new types of ICT applications for CH. Such research could be supported through the ERC, as long as use-inspired basic research is welcomed through that route and not considered purely applied research and discounted as 'close to market'.

Promote a higher degree of inter-disciplinary research and development

In use-inspired basic research, as well as applied R&D in ICT with a focus on cultural heritage, a higher degree of inter-disciplinary work is required. Depending on the research questions addressed, such work will draw on theories, methods and results of other disciplines, such as geosciences, cognitive sciences, linguistics, archaeology, humanities, and others.

Furthermore, in applied R&D there is the need for a close inter-disciplinary working between ICT and cultural heritage professionals if resources are to be focused on the most appropriate ICT research and development. More infusion of CH domain expertise may also raise the likelihood of a successful transfer and further development of research prototypes into market-ready solutions with the potential of a wider adoption in the CH sector. It will also raise the level of ICT competence and awareness in the CH sector.

It is, however, well understood that inter-disciplinary teamwork does not happen by accident, that it requires effort to break out of traditional modes of thinking and working, and that recognition and support is needed to enable such work to flourish.

Exploit the potential provided by ontological modelling and by systematic, empirically-based analysis from many relevant disciplines

It should also be emphasized that there are types of research work that are not technology-focused but are required to create applications with enhanced capability and utility. Such work comprises, but is not limited to, ontological modelling of domains of knowledge and systematic, empirically-based analysis that is carried out in many relevant disciplines. A comprehensive formal ontology of the geospatial domain would allow for representing and processing information about certain types of objects, processes and relations across different levels of scale and granularity and, thereby, considerably leverage the capability of GIS applications (Mark et al. 2004). Systematic analysis of architectural design styles is required as a basis for developing rules for grammar-based procedural 3D modelling. Making use of systematic, empirically-based knowledge about human cognition of space, qualitative spatial reasoning, relationships between natural language, semantics of shape and representations of space, etc. could allow for developing enhanced location-aware services as well as GIS-based applications for 'naïve users' (Jiang and Yao 2006). In short, a lot of potential could remain untapped if the relevance of such research work for creating ICT applications with new or enhanced capability is not considered properly.

Promote research that is needed for understanding CH operational and user situations

There is a great need for research that allows a good understanding of CH operational situations and user issues that involve ICT applications. Expertise in envisaged contexts of use, usability and user experience, likely organizational impact and change, etc. should be brought to bear as early as possible in the R&D for new ICT applications. Often this will be decisive if proposed new systems are to have a chance of being successful with CH institutions and end users. For example, in the development of applications with highly distributed, context-aware

computing and novel types of user interfaces, end users will need to be involved much more and in different ways than is the case in current R&D practice (e.g., prototyping the experience rather than classical user requirements and usability engineering).

Use effective approaches of disseminating and sharing results of the research work

Initiatives to promote progress in research and development for applications of ICT to cultural heritage should consider the most effective approaches of disseminating and sharing results of the research work. Adherence to principles of Open Access to research data and publications as well as Open Source or freely licensed software generally will help make results of research work more readily available and allow for a better return on investment. In particular, if research work is fully, or at least to a large extent, publicly funded researchers should follow these principles. Open Source software will allow not only for re-using software among developer communities, but for potential extension and possibly more sustainable CH ICT applications.

Leverage the offer of CH ICT programmes and courses in tertiary education and training

There is a perceived need to leverage the offer of CH ICT-related university courses and programmes that enable a specialization in this field. The opportunity to acquire an M.Sc. or Ph.D. in cultural informatics is difficult to find in Europe, hence, the level of research-led teaching in CH ICT, i.e., lectures, seminars or the opportunity to participate in research projects, can be considered to be low. Besides measures that could improve the situation at individual universities, European Masters degree programmes with a focus on CH ICT would also be particularly welcome.

4 European frameworks and programmes for R&D in cultural heritage applications

The European frameworks and programmes will play a particularly important role in putting into practice a research agenda for basic and applied R&D in future ICT and applications for purposes that are specific to the CH sector.

Some national programmes will also help in stimulating and giving direction to such R&D. The EPOCH survey 2004/2005 provides an overview of institutional frameworks, funding sources and projects on the national level in 18 European countries, and an attempt was made to better understand identified differences in the participation in European projects concerning ICT applications to tangible CH. (Niccolucci, Geser and Varricchio 2006) But more information specifically with respect to R&D is required to support conclusions and recommendations.

Hence we provide recommendations below on how to align with, and make good use of, European frameworks and programmes that are relevant to R&D in cultural heritage applications.

4.1 The EU Lisbon Strategy, and i2010 initiative

From a European perspective on basic and applied R&D in future ICT and applications for purposes that are specific to the CH sector, the first point of reference is of course the Lisbon Strategy. Launched in 2000, the Lisbon Strategy states that the European Union should become, by 2010, the most competitive and dynamic knowledge-based economy in the world. The development of the "information society" has been placed at the heart of the Lisbon Strategy, with the eEurope 2005 Action Plan (issued in 2002) as a major driver and coordination framework (EC 2002d).

At present, the "i2010 – A European Information Society for 2010" initiative, launched in June 2005, is the European Commission's strategic policy framework in this field. The i2010 initiative centres on three priorities:

- "to create a Single European Information Space, which promotes an open and competitive internal market for information society and media services,
- to strengthen innovation and investment in ICT research,
- to support inclusion, better public services and quality of life through the use of ICT". (EC, i2010 web page)

One of the focus areas is "i2010: Digital Libraries" of which the "European Digital Library" is a flagship project. This focus has become a major reference point of funding programmes such as the eContent Plus programme. In the period 2005–2008, € 60 million of the total budget of € 149 million are made available for leveraging the access to a critical mass of digitized cultural and scientific content across boarders. (EC 2006b/c) (See also Section 9.1)

A programme that should not be overlooked is the ICT Policy Support Programme (ICT PSP) which aims at stimulating innovation and competitiveness through the wider uptake and best use of ICT by citizens, governments and businesses. ICT PSP is one of the main financial instruments of i2010 and will be running from 2007 to 2013 with a budget of € 730 million. It should help develop lead markets for innovative ICT-based solutions notably in areas of public interest.

However, opportunities for basic and applied R&D and related activities are mainly to be found in the Information and Communication Technologies (ICT) theme of the 7th Framework Programme.

4.2 The 7th Framework Programme for Research and Technological Development (2007–2013)

The 7th Framework Programme for Research and Technological Development (2007-2013) with a budget of € 54.6 billion is the European Union's main instrument for funding research and development and fostering growth and integration of the European Research Area. Actually, it comprises four programmes "Cooperation", "Ideas", "People" and "Capacity". "Cooperation" (collaborative research projects) with € 32.3 billion has the largest budget and the Information and Communication Technologies (ICT) theme with € 9.12 billion the largest share in this budget.

FP7 "Cooperation" – ICT theme

The ICT theme of the 7th Framework Programme (FP7) has as Challenge 4: Digital Libraries and Content, and it is understood that R&D work carried out under this Challenge should contribute to the implementation of the "i2010:

Digital Libraries" initiative. In the FP7 Work Programme 2007-2008, a total budget of € 203 million has been earmarked for this Challenge in the first and third calls. The ICT objectives under Challenge 4 are "digital libraries & technology-enhanced learning" and "intelligent content & semantics". The expected share of "digital libraries & technology-enhanced learning" in the first and third calls together is € 102 million. (EC 2006a)

It seems worth noting, that "cultural heritage" is not considered as an objective in its own rights, rather, "digital libraries" of cultural, scientific and other content have become the focus point. The Work Programme's Objective ICT-2007.4.1 (ICT-2007.4.3): Digital Libraries and Technology-enhanced Learning under "digital libraries" asks for cooperative research work with the target outcome in the medium term described as follows:

> "Large-scale European-wide digital libraries with innovative access services that support communities of practice in the creation, interpretation and use of cultural and scientific content, including multi-format and multi-source digital objects. They should be combined with robust and scalable environments which include semantic-based search capabilities and essential digital preservation features. Particular attention is given to cost effective digitization processes and to the use of digital resources in multilingual and multidisciplinary contexts."

Furthermore, research proposals with a longer term outcome of "radically new approaches to digital preservation" have been invited, and a "specific focus" has been placed "on the creation of a network of centres of competence for digitization and preservation, building upon, pooling and upgrading existing resources in the Member or Associated States". (EC 2006a, 34-35)

These are very important objectives and, indeed, we will argue that digital libraries with content in 3D formats will pose particular medium and longer-term research challenges, and that centres of excellence in 3D digitization will be essential nodes of European digital CH networks.

Yet, it should be noted that the present focus on digital libraries does not cover some fields of R&D that are of particular relevance for ICT applications for visitors of monuments, sites and museums, augmented and mixed reality applications, context-aware and ambient intelligence environments, for instance.

Research in such fields may be proposed addressing technological objectives under other FP7 challenges such as Pervasive and Trusted Network and Service Infrastructures and Cognitive Systems, Interaction, Robotics, and CH environments will provide an equivalent, or even better, case for testing and trialling prototypic applications as any other.

FP7 "Ideas"

A new opportunity also for ICT research with a focus on CH is provided through the "Ideas" strand of the 7th Framework Programme which invites "investigator-initiated frontier research" executed by individual teams that typically will cut across established disciplinary boundaries and national borders. The sole criterion for selection of research proposals is scientific excellence. The programme has an overall budget of € 7.5 billion over 7 years (2007-2013) and is managed by the newly established European Research Council (ERC). On average € 1.073 billion per year will be granted to innovative projects headed by starting and advanced researchers in all fields of knowledge and scholarship. In the first call under the Starting Independent Researcher Grant scheme, 9167 applications were submitted, of which 559 were selected to submit a full application. (ERC 2007, 3-4) It will be interesting to see if among the "frontier research" projects that receive a grant any will tackle research topics of, or related to, this Research Agenda. However evidence from competitive calls for research projects, spanning 50 years or more, is that in highly competitive, use-inspired research is treated as "close-to-market" and tends to receive lower ratings (see Stokes, 1997 for discussion).

FP7 "People" and "Capacity"

In the "People" strand of the 7th Framework Programme € 4.7 billion are made available for developing human potential and mobility of researchers, in particular, through increased funding for Marie Curie actions. To ensure a high level of European R&D with a focus on CH applications will also require offering young researchers good opportunities for mobility and training as well as retain in or recruit to Europe highly talented researchers. CHIRON (Cultural Heritage Informatics Research Oriented Network), a Marie Curie Early Stage Researchers Training project coordinated by EPOCH partner PIN scrl (Italy), is a remarkable effort at meeting these aims. The Network runs from Dec 2004 to November 2008 with a budget of € 2.3 million and provides research training fellowships for graduates wishing to start a research career in the field of ICT applications for purposes of tangible CH. It is hoped for that similar mobility and training opportunities can be offered also in the future.

The "Capacity" strand of the 7th Framework Programme receives € 4.1 billion for projects in a variety of fields such as research infrastructures, regional research-driven clusters, research potential of Convergence Regions, science in society, and international cooperation. We will not go into details with respect to this part of the 7th Framework Programme. But it may be of interest to note that the budget of € 1.665 billion that is allocated to research infrastructures may be too small, given that the intent is to support existing as well as new infrastructures. (cf. Dias and Fabianek 2007)

4.3 Important related instruments

European Research Infrastructures
The European Strategic Forum on Research Infrastructures in October 2006 has published the European Roadmap for Research Infrastructures that documents suggested new and major upgrades to existing infrastructural resources. (ESFRI 2006) The estimated required investment for these pan-European research infrastructures is € 14 billion over 10 years. Some of the 35 research infrastructure projects (facilities, research equipment, databases, and networks) are relevant to R&D projects in CH ICT, in particular, those with a focus on social sciences & humanities. For example, the Common Language Resources and Technology Initiative (CLARIN), the Digital Research Infrastructure for the Arts and Humanities (DARIAH) or the European Resource Observatory for the Humanities and Social Sciences (EROHS). A further interesting venture is Research Infrastructures for Cultural Heritage (RICH) that has been developed by European centres of research in advanced lasers, neutrons and synchrotron radiation technologies which can be used for non-invasive examination of cultural heritage objects. (Andreani et al., 2006)

European Technology Platforms
There are now over 30 European Technology Platforms (ETPs) at various stages of development. (EC 2007d) ETPs are predominantly led by industry and made up of representatives from the private sector, academia and other interested stakeholders. They develop a common vision and established a Strategic Research Agenda (SRA) in a specific area of technology, and seek to influence industrial and research policy and public and private investments on R&D in priority areas of their SRA. It could be useful to establish closer relationships with ETPs that are relevant to research topics in CH ICT. To provide but two examples, with respect to 3D content a particularly interesting ETP is Networked and Electronic Media. (NEM 2007); regarding applications for the integrated management of CH, the European Construction Technology Platform could be of interest (ECTP 2005, 28-31).

5 Scenarios for future ICT systems for CH practitioners

For the development of the Research Agenda a scenario approach was chosen to allow for envisaging future ICT systems that might be of particular relevance to the Cultural Heritage Sector as well as identifying areas of ICTs that require additional research to support the scenarios. This chapter presents the results of this work.

The five hypothetical future scenarios for particular work situations involving cultural heritage professionals are:

- Scenario 1: Site excavation – virtual excavation support teams
- Scenario 2: Community museums – hybrid eco-museum and community memory
- Scenario 3: Educational experiences – heritage classrooms without walls
- Scenario 4: Heritage management
- Scenario 5: Environmentally endangered sites – large-scale industrial heritage site.

For developing each scenario:

1. A brief story presents the scenario in a specific area of the heritage sector;
2. A commentary on the scenario provides background for its relevancy to the CH sector, explores variations in the underlying issues, and describes general trends regarding ICT needs;
3. The ICTs and ICT-supported processes that are implied in the scenario are summarized in a tabular overview to allow for identifying aspects which may require additional technological research in order to realize them.

In the section which follows the technological research requirements of all the scenarios are then drawn together and the implied technological developments that lie behind the future CH work situations described are summarized.

Part of the overall technology need will be met by generic developments which can be expected to be the objective of developments in the wider ICT industry. For the purposes of the EPOCH Research Agenda we concentrate on isolating those developments that require research and development which is specific to the cultural heritage Sector.

A foreword to the scenarios by Neil Silberman, Ename Centre for Public Archaeology and Heritage Presentation

The normal administrative methods of arriving at consensus in matters of official heritage policy are unlikely ever to address the most challenging and far-reaching directions that research could potentially take. Governmental heritage services and international conservation organizations already bear a significant burden in simply in keeping up with the day-to-day challenge of conserving and safeguarding the world's material heritage. But a longer-term vision of the 'Future of Heritage' requires forms and modalities of recording, analysis, interpretation, and public dissemination that go far beyond those already available. The watchwords are place, network, memory, identity, and communication. Obviously technology can and will provide the context and tools for these new approaches to heritage.

From a strictly cultural heritage perspective, the big changes to be anticipated in the next 10 years or so are unlikely to be about automation but rather about systemic changes in the way our heritage is categorized, protected, and interpreted. This will probably include the gradual dismantling of the rigid top-down structure of most heritage institutions and authorities and a much greater concentration on networking at the regional and even local level. The growing movement for 'Heritage Ecology' – namely the recognition of the fragility and non-renewability of material remains from the past – is at least partially influenced by globalized information exchange about endangered sites and more general environmental and human threats. This Research Agenda seeks to balance the consumption of cultural heritage resources by accelerated digital capture, digital excavation, and elaborate presentation techniques with the conservation of that same heritage. This can be done through the development of an innovative, ICT-enabled stewardship of the world's cultural heritage resources through monitoring, enhanced and sustainable documentation, new communication networks, and more powerful knowledge discovery tools.

The scenarios below are intended to highlight major challenges facing cultural heritage professionals and others involved with cultural heritage as working methods and opportunities develop over the next 10 years or so. The challenges involve the practical requirements of several heritage subfields: scientific research, museology, education, management, and environmental protection. In some ways the biggest challenges involve the embedding

of technologies effectively and seamlessly into the working practices of professional disciplines that have been educated, deliberately and appropriately, to be conservative. At the same time the future directions that will become enabled by these developments have the potential to transform both the working lives of professionals in the sector and the public's appreciation of, and engagement with, their own heritage.

5.1 Scenario 1: Site excavation – virtual excavation support teams

5.1.1 Scenario – story

Early morning in a harbour town in Sweden:

Jan Anders, a junior archaeologist, has not had much sleep over the last few days. He is working at an excavation site that will be destroyed next week in order to proceed with the building of a new bridge in the harbour area.

When preparing the fundaments of the bridge, remains of an old tunnel were detected. This tunnel was used in the 16th and 17th centuries to transport goods on small boats to a marketplace in the centre of the town, but was abandoned after a relocation of the marketplace.

Jan was allowed, together with two volunteering students, to dig deeper into the tunnel, which is filled with mud. This morning they found five coins which seemed to be not of Nordic origin. Furthermore, some fragments of pottery and fabric appeared of which the fabric also seemed unusual for this area. However, Jan also noticed that the ceiling of the tunnel could be rather unstable.

Therefore, he decides to ask for help from the International Virtual Excavation Agency (IVEA) to get information about the finds, and whether he should invest the effort to stabilize the walls and try to rescue possible further interesting finds.

Using the hand-held 3D scanner from his portable excavation support set, Jan scans the pottery fragments and uploads them together with photographs of the coins onto the IVEA database.

In the meantime, the IVEA has issued a call for assistance which describes the local situation and required expertise. Within two hours a group of experts in numismatics, pottery and fabrics joins in a virtual environment equipped with a digital archaeology workbench and access to relevant databases from around the world.

For the coins a quick result becomes available through using automatic digital image comparison technology. Intriguingly, they prove to be Spanish coins from the late 17th century.

In parallel, pottery experts run the 3D objects of the shards through an application that suggests various likely shapes of the pottery. This demonstrates that one potential match suggests that the pottery could be of Spanish origin and the virtual reconstruction takes this into account. But other results are inconclusive and do not verify the hypothesis. The most convincing results suggest that the pottery is a wine jug and after comparison with images of typical Nordic jugs of the 18th century the experts confirm this finding as the most probable.

Meanwhile, Margret, an expert in the acquisition of chemical data, assists Jan with the conservation and analysis of the fabric, which is in danger of rapid deterioration. Jan is not acquainted with the infrared microspectroscopy tool available in the excavation support set. However, Margret guides him through the process as she can observe remotely Jan's handling of the tool. Margret's analysis of the data establishes that the fabric is damask and has traces of substances associated with crimson pigment.

The results are reported by Jan to the responsible municipality department, and the decision is taken to shore up the site and explore it further; however, no further related remains are found over the following days. The 3D objects, photographs, chemical data, expert comments and annotations are assembled into a multimedia record of the excavation, which is stored in the IVEA database of completed excavations.

One month after the tunnel was destroyed in the construction of the foundations for the new bridge another piece of information is added. A city archivist who heard about the excavation sends Jan a scanned page from an old manuscript containing a few interesting lines. In the year 1712 a Spanish nobleman who visited the town with a group of merchants disappeared without a trace…

5.1.2 Commentary and implications

Today, bringing together a multi-disciplinary team of highly specialized experts is something most small, low-prestige excavations will not be able to afford. However, technologies such as the ones described in the above scenario can allow for forming ad hoc teams of experts as required in different phases of an excavation.

Virtual excavation support teams can not only bring required expertise to remote sites, they can also considerably speed up data acquisition, analysis and interpretation and thereby decrease the costs of excavations. Moreover,

in the case of rescue excavations, using a virtual excavation support team can help in supporting local decision-making and prevent a possible loss of valuable archaeological information.

Technological requirements for this on the one hand are tools for rapid on-site data acquisition and, on the other hand, a virtual environment that supports the remote experts in comparing and analysing data, exchanging opinions, and rapidly testing hypotheses.

In critical situations such as rescue excavations the responsible heritage administration will need to be involved also in the ongoing evaluation and interpretation of excavation results.

The need in the coming decade will be for technology to facilitate shifting constellations and collaborations of scholars – creating virtual multi-disciplinary communities that can rise and fall according to specific research needs. Yet they will leave behind a growing body of data produced through this multi-disciplinary synergy. In particular this means on the scientific level that formerly large excavations in most places are likely to become clusters of relatively small projects led by a variety of researchers and institutions. No more Great White Explorer watching the basket boys carry the dirt away, but shifting constellations of research and administrative interests that will deal with a variety of issues: scientific research, conservation, heritage administration, public interpretation.

So the key to the usefulness of a mobile device in the field will be to help the information flow from primary collection to relevant (and interlinked) repositories of analysis, conservation, management, and public interpretation. Anders, the field user in the scenario – a junior archaeologist on the staff of a busy municipal archaeological service – must and will be educated in a new way to be conscious of the various aspects of the discovery of unexpected evidence. That is, he (or she) will be much more familiar with the post-excavation processes and will be educated to understand that traditional antiquarian studies are just a small part of the picture.

This scenario highlights the need to transform a view of the technology from the PDA as just an electronic field notebook of the traditional kind to become a vital communication link between the primary researcher and the growing range of information and expertise worlds involved in heritage.

Table 5.1 highlights the range of technologies already implied in the scenario presented. The broader category of working situations that this scenario represents will imply additional technologies and processes that could have been included in similar situations.

At the more generic level this scenario highlights the needs for:

- Mobile access to
- Integrated, but distributed, resources and
- Distributed expertise, informed by common views of the available information.
- A variety of novel on-site data capture devices, capable of supplying different types of data and information to the collective and integrated enterprise.

Underpinning this scenario is a vision of a distributed research team with a variety of information needs, accessing data from distributed repositories from different perspectives. Their expertise is being applied to a combination of data direct from the site and that already held in the repositories. Finally there is an implication that their work will be used to influence the management of the ongoing excavation, and may change the directions of the onsite work, enabling more effective decisions to be made about site excavation strategy.

The scenario reflects a common current situation where substantial, but partial, documentation exists about a site and a great deal of research currently would be done from documentary sources to aid planning before the onsite work begins. The scenario extends this process to allow use of data collected from the site to try to evaluate the relationship between the existing documentation and physical remains being uncovered and provide feedback from remotely located experts to adapt the onsite management of the excavations. Such changes might link the existing descriptive text in the documentation to the physical location where that was not described precisely in the documents (as is normally the case).

Other variants of the scenario requiring similar organizational and technological support might involve endangered sites and rescue archaeological investigations, whether for site development reasons or in the face of other climatic, environmental or political threat.

5.1.3 Overview of specific technologies/applications and processes implied in Scenario 1

Technologies/applications	Details of applications and processes
Portable excavation support set	
3D scanning technology:	Hand-held 3D scanner
Portable infrared microspectroscopy tool	Acquisition of chemical data of fabric
Virtual environment and digital archaeology workbench for a multi-disciplinary group of experts (numismatics, pottery, fabrics, etc.)	Evidence-based scientific research: verification/ falsification of hypothesis
Automatic image recognition and comparison technologies	Comparison of photographs of coins
3D virtual reconstruction	Application suggests various likely shapes of pottery based on available 3D objects of pottery fragments, also taking into account information on pottery from different regions Comparison of 3D objects with images of pottery
Micro analysis of finds	Analysis of microspectroscopic chemical data (e.g., type of fabric, colour pigments, etc.)
Interpretation of finds	Expert comments and annotations of objects
(Semi-)automatic metadata creation	Metadata standards
Communication	
Call for assistance	Presentation of information about local situation and required expertise
Communication with in-field archaeologist	e.g., for carrying out micro analysis of finds
Communication among experts in/via the virtual environment	e.g., for interpretation of finds
Remote expert guidance in handling a tool	e.g., for acquisition of chemical data
Databases	
Database access	Access to distributed databases containing 3D objects of pottery, photographs of coins, information about chemical properties of fabric, etc.
Upload of content and metadata	Upload of digital information/objects to a central database – 3D objects of pottery fragments – Photographs of coins – Data about chemical properties of fabric
Aggregation and storage of complex multimedia object	Assembling, describing and storing: 3D objects, photographs, chemical data, expert comments and annotations Adding an archival record to a complex multimedia object
CH management	
Decision-making on an ongoing excavation	Reporting to a municipality department in charge of local heritage

Table 5.1: Overview of specific technologies/applications and processes implied in Scenario 1

5.2 Scenario 2: Community museums – hybrid eco-museum and community memory

5.2.1 Scenario – story

Maria Bauer is a curator of an eco-museum in one of the alpine regions of Europe. Three years ago, the region had planned to build a museum; however, it had been decided otherwise after Maria together with Max Frisch, an energetic owner of a small IT and digital media company, had presented a plan for developing a 'museum without walls' for and with the people of the region.

Representatives of the local municipalities were very sceptical. However, the museum concept and technical set-up proposed by Maria and Max proved to match much more closely the politicians' notion that a museum should promote the region to tourists.

The basic concept was that the whole region with all of its landscapes, local agriculture and traditional businesses, celebrations, objects of daily life, stories about places and events, cherished private objects, family albums and so forth is declared as Living Heritage of the region.

No objects are transferred to a museum, they remain where they are. No physical exhibitions of artefacts and visual representations are organized and presented. Instead, the technical set-up of the eco-museum allows for capturing, assembling, presenting and accessing digital representations and narrations of the region's heritage.

Maria's main task is to visit locals who want to 'donate' objects, images and stories to the collective museum. Today, she has visited a retired blacksmith who donated some of his instruments, a family album and stories about what it meant for him, his father and grandfather, all of them blacksmiths, to earn a living in the region.

Over the last few years the eco-museum has scanned thousands of photographs from family albums, scanned many unique and typical objects (3D) of the region as well as photographed landscapes, buildings, places and objects in villages and along streets and routes through the mountainous parts of the region. Hundreds of stories (written and recorded) about objects, places, and social life in the region have been collected, many of which have been collected through oral history projects at schools, which directly upload the stories to the eco-museum's database (cf. Giaccardi 2006 on the key role of storytelling for the collective memory of a region).

A deep sense of ownership has emerged among the people of the region. This also extends beyond the local community, because photographs, postcards, transcribed letters, and recorded stories are also donated from people around the world whose ancestors had emigrated from the region.

The technical set-up of the eco-museum comprises:

- Digital objects (3D objects, photographs, stories about places and events, etc.), which are all geo-referenced.
- The digital entities are represented on a Web-based map of the region that can be panned and zoomed into and for each object descriptive metadata and a direct link is provided.
- Speech recognition and text-to-speech conversion technology and semantic processing are employed and some of the metadata is automatically extracted from the stories using multi-lingual natural language processing technologies.
- Stories related to similar objects or events can be identified, browsed, selected, packaged and downloaded for more detailed study.
- Local historians, teachers, students, parents and grandparents form virtual communities that engage in the study of historical developments in the region and organize virtual exhibitions that represent the past, present and likely future meaning of collective heritage from different perspectives.
- The museum also is part of a European Network of Eco-museums, the members of which share digital objects and stories, explore common cultural and socio-economic topics, and create virtual exhibitions on common themes. Such exhibitions make use of enhanced machine translation and multilingual data processing tools.
- Based on the geo-references, stories about, and historic photographs of, places, buildings and objects of the regions can also be accessed through mobile devices.
- For locals and tourists the digital resources provide an opportunity to gain a deeper understanding of the region, its tangible and intangible heritage and collective memory.

5.2.2 Commentary and implications

Since the 1980s many regions have embraced and realized in different ways the concept of eco-museums. The term was coined by Hugues de Varine in 1971, and one of the realizations of the concepts has been the 'Musée de l'Homme et de l'Industrie' in Creusot-Monceau-les-Mines, which opened in 1974 (cf. Varine 1993; for a systematic description see Davis 1999).

According to the Laboratorio Ecomusei of the Regione Piemonte at present there exist about 230 eco-museums in Europe, most of which are located in France, Italy, Portugal, Spain and the Nordic countries (cf. the maps and lists at Ecomusei.net; for a detailed presentation and discussion of the development of eco-museums in Europe see Maggi and Falletti 2000).

Museum doyen Kenneth Hudson about 10 years ago suggested that Europe is "…a giant network of potential eco-museums" (Hudson 1996). In fact, the concept has much future potential, particularly through the use of novel technologies that allow for effectively representing the collective heritage and memory of a region. The success of the local museum in the next decade is going to depend on how effectively it can function within a community context. It can no longer be just a 'show' or a 'tourist attraction', but needs to be an integral part of the community.

Work such as that of the HICIRA Network (www.hicira.org) has shown clearly that local museums (and especially local site museums) are going to move away from the static displays of artefacts and concentrate on establishing the structures for the creation of long-term, sustainable local memory institutions, in which the input of the public is central. This view is supported by some policy work (e.g., the UK Department of Culture, Media and Sport's recently issued document *Understanding the Future: Priorities for England's Museums* (DCMS 2006b). Many best practice examples can be found among the more than 1400 projects in the UK that between 2000 and 2006 received small grants from the Local Heritage Initiative (http://www.lhi.org.uk) to document and celebrate their local heritage. The initiative's *Tell it as it is* guide provides useful guidance on how to create digital content for its LHI Web page (TIAS 2003).

The local museum will, as always, be struggling for budget to sustain an environment in which the community will be recording and identifying with its own heritage. The budget to equip the museum for this role may be drawn from ticket sales and other revenue streams based on visitors (including school groups and tourists), or it may receive a revenue contribution from the community role. However, there is no evidence to suggest that these revenues will be less stretched than budgets are at present and there will be an enhanced role to sustain. The key to the future is likely therefore to be as much about enhancing the sharing of tools and activities with associations of museums in similar circumstances as it is about sharing artefacts and information.

It is likely that in 10 years' time local museums will no longer be the poor and primitive shadows of the great national museums, but will be an active force in their own right in the heritage field – acting together in clusters to participate in original temporary exhibitions and sharing online educational programmes (with the hierarchy of local, regional, and national museums becoming less rigid and not so much the source of all museum trends). This is the evolution that technology can and should facilitate.

In this scenario technology has to enable and maintain, in a slightly different form from the first scenario, the creation of virtual communities as much as virtual objects. In addition, sharing information across collections will assist in the definition and assembly of collaborative exhibitions.

Alternative versions of the scenario involved trying to tie in a locally discovered artefact with its distant origins and establishing the cultural historical connection. The reverse could also be true. The community might be want to locate artefacts and information concerning its own heritage that have migrated elsewhere and link them with memories in the community. If the community is one of oral traditions (e.g., in aboriginal Australia or Africa) then the memories might result from generations of storytelling and require interpretation. The lost artefacts and associations might be distributed through a colonial power and via colonization and trading routes. The scenario might actually relate to orphaned heritage (cf orphaned works in copyright terms) where both the colony and the colonial power have part of their heritage displaced and not very well appreciated. In this context the notion of digital repatriation and shared memories of the colonists and the colonized might form the basis of new and ongoing interaction which serves to help current generations appreciate their country's colonial past and identify the inheritance of that past in the country of today.

In a scenario, any specific hypothetical example which required linking of a specific significant artefact with a remote location and/or bygone time could be considered contrived. However, the vision must be of a distributed environment involving integrated views of locally-held collections searchable on a common basis based on complex search criteria and characteristics (e.g., shape).

Table 5.2 highlights the range of technologies already implied in the scenario presented. The broader category of working situations that this scenario represents will imply additional technologies and processes that could have been included in similar situations.

This scenario therefore highlights the needs for:

– Systems for capturing, analysing and interrogating user-created content based on a variety of media including speech, storytelling, dance and music;
– Integrated, but distributed, resources (both in terms of digital records and physical artefacts);
– Data capture of physical artefacts;
– Recreation/simulation of mechanisms from industrial heritage and the context of their use.

Extrapolating the potential demands would involve extremely complex and long-term research questions, for example to define advanced search characteristics and mechanisms (e.g., mechanisms to search music or dance for particular structures in the plots of stories in order to detect common oral heritage which may have diverged over generations of retelling).

5.2.3 Overview of specific technologies/applications and processes implied in Scenario 2

Technologies/applications	Details of applications and processes
Digitization technology	3D acquisition, etc.
Geo-referencing	All digital objects (3D objects, photographs, stories about places and events, etc.) are geo-referenced
Map-based access	The map can be zoomed and for each object descriptive metadata and a direct link is provided. Similar or related objects and stories are indicated and can be browsed, selected, packaged and downloaded for more detailed study.
Databases	3D objects Photographs Stories – text Stories – voice Music Dance Other
Metadata	Base descriptive metadata standards (Semi-)automatic extraction of metadata from written and recorded stories
Speech recognition and text-to speech conversion technology	W.r.t. stories
Technologies for identification of similarity objects (not based on metadata)	– For images: Image recognition and comparison – For 3D-objects: Shape-based identification
Technologies for identification of relatedness of stories (not based on metadata)	– For texts: Commonly used names (of places, objects, etc.) or common story structures – For voice: Commonly used names of places, objects, etc.
Machine translation and multi-lingual data processing	W.r.t. collaborations in a European network of eco-museums
Mobile devices and positioning technology	W.r.t. accessing geo-referenced stories and images
Virtual community and exhibition technologies	Study historical developments in the region and organize virtual exhibitions that represent the past, present and likely future meaning of collective heritage from different perspectives. Exhibitions of networks of eco-museums in Europe and beyond
CH Management	Community-based

Table 5.2: Overview of specific technologies/applications and processes implied in Scenario 2

5.3 Scenario 3: Educational experiences – heritage classrooms without walls

5.3.1 Scenario – story

Julia, Paul, Philip and Veronica, 15- and 16-year-old students from a secondary school, take part in a 'museum without walls' project at the city museum. Together with staff from an interactive media company, a curator and the educational programme manager of the museum they work as co-designers of interaction concepts, story-boards and applications which should allow for better mediating knowledge and learning about cultural developments and experiences in the city.

It's the second time that the group works on what the company calls 'experience prototyping'. This methodology concentrates on the potential users' interactions with the novel applications and aims to ensure that the users' experiences and learning processes are engaging and culturally enriching.

The students' idea is to engage school classes in comparing the lives of young people in the city centuries ago with the experiences of today. Students would also find out about their grandparents' childhoods by interviewing them, produce digital images of photographs from family albums, and illustrate with objects cherished by the family and which in some cases appear in the old photographs.

Together with the staff of the media company and the museum curator the group of young co-designers will develop 3D storyboards of how the future users of the 'museums without walls' will interact with the information environment they conceive. They want to make use of virtual narrators, avatars of a boy and a girl that can appear on the screen of any interaction device (e.g., a mobile phone, a kiosk system, a TV set; etc.) and tell stories about places, streets, buildings and objects from the young person's perspective.

The educational programme manager suggests that an avatar should only tell a story if people provide it with a digital image and comments. (For example, this has been a major factor in the assemblage of a library of documented tourism images by the community of teaching staff in tourism studies – see www.tourismimages.org.uk). The images can be geo-referenced and shown with text received via a mobile phone or chosen from the museum database.

The design team also wants to establish kiosks at certain places in the city, such as the central railway station, where visitors can meet the avatars and get information or stories from them by pointing to a place or street on a map, an image or certain parts of an image.

However, the students think that, ideally, all buildings, streets and objects in the city should be able to tell their history and stories about life in the city today as well as many centuries ago. The visitors would not necessarily need to interact with avatars at special places such as kiosks. Instead, they would wear special spectacles for perceiving changes in the environment through the centuries (augmented reality) and listening to stories a building or place relates directly to them.

5.3.2 Commentary and implications

Systems for mediating cultural heritage knowledge on the one hand will need to be able to handle increasingly complex information environments and, on the other hand, make sure that the cultural experience and learning is stimulating and engaging for the users. The latter is of particular importance if the goal is not only to allow for enhanced access to digital cultural heritage resources, but also to invite users to provide their own content and stories to a learning environment such as the one described above.

With such environments the heritage sector becomes part of the so called 'experience economy' in which customers of service, media and entertainment industries seek unique, meaningful and memorable experience (cf. Pine and Gilmore 1999; Schmitt 2001). Hence, cultural heritage organizations need to develop novel concepts of cultural experience and learning that inspire, engage and enrich the users of their resources, which can be achieved with greater predictability if the users participate in the creation of the experience and begin sharing own content and stories.

While such concepts are likely to make use of a new generation of 'ambient intelligence' (i.e., distributed, embedded and context-aware computing and novel interfaces, in the development of effective concepts, the potential users will need to be involved in a more qualitative and effective way than by carrying out some user testing before launching a new tool or service.

This has been emphasized by the IST Advisory Group with respect to future ambient intelligence systems and applications. They suggest that research and technological development will increasingly need to make use of 'experience prototyping' which focuses on the quality of the users' interactions and experiences. They write:

> "Requirements engineering for Ambient Intelligent systems design can no longer be seen as a task that can be accomplished through the development of scenarios and the translation of use cases into system requirements. System functionalities that generate true user experiences can only be determined in a reliable way from feasible prototypes providing proofs of concept. New approaches to prototyping are likely to be key to the successful development of AmI products and services" (cf. ISTAG 2003, 27–29; ISTAG 2004).

Experience prototyping should enable design teams, users and clients to gain first-hand appreciation of existing or future conditions through active engagement with prototypes. This extends well beyond the kind of scenarios, use cases, requirements engineering for software design and usability studies that are in practical use today.

Historically a major defining purpose for museums has been the education of the public – a role which is continually developing and where further revolutionary change can be anticipated. DigiCULT has already explored this quite deeply (http://www.digicult.info). Cultural heritage institutions across the world are exploring a variety of educational approaches including e-learning, lifelong learning, and neighbourhood and cross-generational learning groups. In all of these, heritage education will move away from traditional heritage didactics to training children (and their parents and grandparents!) to work with concepts and know how to contribute to the historiographical process.

This scenario features a natural evolution away from the traditional school visits with groups of children equipped with clipboards and pencils making notes from the museum collection for inclusion in a home report, towards a more visionary 'heritage classroom without walls' of the future. In this future hypothesis the tools that the teachers/facilitators will need will be those that bring generations together to create and productively help the evolution of historical knowledge and collective memory. They will integrate with those of the previous scenario and with school-based systems which put the work undertaken into context for curricula and learning objectives.

The key will be not merely to help students memorize or mimic 'expert' opinion, but to create their own perspectives – perhaps by participating in online initiatives in which local values can be stressed and local resources selected – and these must be carefully integrated into national curricula. Following the specific exercise and follow-up work the students' work might be completed by presentation of the results of their findings using a variety of digital presentation media, again linking to other areas of curricula.

The research challenges here are clearly linked to those in the previous scenario, but in this case with the added dimension that many of the tools must be usable by students of all ages, and their teachers, directly. Thus the mediation and support that the curator and museum staff might offer will be delivered one step removed by the educational establishment. In addition some of the offsite work might well be undertaken by students using a mixture of resources at, or from, home. This is both an interfacing challenge to operate with users of all ages, and also a challenge in delivery which would need to be sufficiently ubiquitous and easy to allow equal participation by different socio-economic groups.

Table 5.3 highlights the range of technologies already implied in the scenario presented. The broader category of working situations that this scenario represents will imply additional technologies and processes that could have been included in similar situations.

This scenario therefore highlights the needs for:

- Systems similar to those required for the previous scenario for capturing, analysing and interrogating user-created content based on a variety of media but particularly speech and storytelling;
- Similar integrated, but distributed, resources (both in terms of digital records and physical artefacts);
- Interactive delivery systems for accessing resources from the home, based on technology convergance;
- Interfacing technologies enabling novice and non-specialist users to be creative with the resources and assemble presentations drawing on and relating concepts from multiple sources;
- Engaging presentation software and hardware technologies to enhance the learning experience;
- Integration between learning environments and museum resources.

5.3.3 Overview of specific technologies/applications and processes implied in Scenario 3

Technologies / applications	Details of applications and processes
3D storyboarding	Used to outline the interaction of users in a hybrid information environment Allow for rapid 'experience prototyping' focused on the quality of the users' interactions and experiences
Geo-referencing of images and texts	For location-aware provision of historic images and stories
Database of museum and user-generated content and metadata	In addition to the more widespread issues of identification of co-referencing through multiple heterogeneous, multi-lingual, and multi-cultural sources, user-created content further complicates the automated systems by introducing terminology, vocabulary and concepts that may not exist in standardized cultural heritage thesauri, taxonomies and ontologies. The user generated content will often be categorized and tagged by the users themselves. The creation and management of such 'folksonomies' will be supported by novel, semantics-aware applications. The volume of data collected in this fashion also means that summarization tools would be useful as a means of compressing the volume of data
Text to speech conversion technology	To convert user submitted stories in text format to natural language narration of avatars
Virtual narrators, avatars	The avatars can appear on the screen of any interaction device, e.g., a mobile phone, a kiosk system, a TV set, etc. Storytelling about places, streets, buildings and objects from a child's perspective
Kiosk systems	Where visitors can meet avatars and ask them for stories
Multi-modal interaction	e.g., pointing to a place or street on a map or an image or certain parts of the image to trigger narrations
Augmented reality	Spectacles for perceiving changes of the environment through the centuries (and listening to the stories of a building or place)
Ambient intelligence environment	Buildings, streets and objects able to tell their history and stories about historic life in the city

Table 5.3: Overview of specific technologies/applications and processes implied in Scenario 3

5.4 Scenario 4: Heritage management in the context of major events

5.4.1 Scenario – story

It is 2016 and the Lord Mayor's office in London is planning how to handle the expected influx of visitors accompanying the hosting of the 2018 Football World Cup. The city had learnt much from hosting the 2012 Olympic Games and there is concern about the additional traffic at the city's principal heritage visitor centres. In 2012 experience was gained in the management of visitor demand through selective investment in visitor attractions associated with the less frequented heritage sites on the periphery of the city. Venues such as Hampton Court Palace, Kew Gardens and Greenwich had been busier than usual in 2012 but had failed to any great extent to alleviate the exceptional traffic at the Tower of London and other central venues.

As a result of these experiences better computer models of visitor demand have been developed and an integrated strategy is being debated which is designed to encourage the visitors to go to the venues closest to their accommodation. The enormous numbers of expected visitors would mean that all accommodation over South-eastern England is expected to be fully booked and strategic marketing of the accommodation is being planned

to minimize the likely travel between accommodation and the match venues. At the same time local investments in visitor experiences and marketing local visitor venues in packages with the adjacent accommodation is being planned as an integrated solution to spreading loads.

The planning is taking into account the mix of nationalities expected to be represented in the finals and at the venues in which the teams will play new cultural experiences are being developed which address England's cultural interaction with relevant parts of the world. These experiences are being designed to emphasize positive elements of Britain's interactions with each region and downplay the many historic conflicts. Careful research has been commissioned to discover and retell appropriate stories and designers have been retained to turn these stories into engaging experiences. Emphasis is being placed on historic trade connections and on the human stories and cultural influences spread through trading. The stories are to be brought to life using large scale immersive displays and novel interactive technologies.

In parallel to the research into appropriate story lines local and regional museums are being identified and special exhibitions planned. To accompany the stories special collections are to be assembled with the artefacts drawn from national collections. The integrated information sources developed in the last 10 years are being used to identify the most appropriate artefacts and weave the information about them into the stories. The series of special exhibitions and visitor experiences is being planned to complement a full social programme and other visitor opportunities include sport and recreational activities.

Today there is an early design review in which the stories are being reviewed, venues identified and the associated special collections being proposed. The 10-person planning group comprises the Lord Mayor (Ken), the Head of the Museums Service (Pauline), the consultant historian (John), the professional writer (Andrew), the lead exhibition designer (Jasper), the Head of Tourism London (Adam), the chief technology advisor (David), the CEO of London Transport (Shirley), the Deputy Commissioner of the London Metropolitan Police (James) and a senior representative of the hotels association (Angelina).

The main purpose of this meeting is to decide outline budgets for investment and expected returns. The meeting is also to consider an imaginative proposal to exploit potential sharing of the experiences via networked systems with related complementary experiences in the competing countries. Part of the argument in favour of the investment in these systems is presented as the residual value of the technological investment after the event is over, but Ken is unconvinced by the early analysis and has asked for more socio-economic impact analysis on this aspect. The links so established may also be used for closely linked relaying of the World Cup matches….

5.4.2 Commentary and implications

In this scenario the region is supposed to be representative of many heritage regions in Europe where a few high profile venues attract the majority of the visitors, but in this case a large influx of visitors to the region is predictable and inevitable. The expectation is that major wear and tear might be placed on very specific venues and the authorities are keen that the visitors have an enjoyable experience, but concerned by the potential damage to unique assets whilst other, less-valued, venues are not used to capacity.

Much of the solution to this problem is a straightforward question of visitor management and transport and other capacity planning, but in this case the hypothesis is that the planning process may be assisted by tools which allow both prediction of the attraction each site is likely to present to the visitors and the degree to which this can be impacted. Thus the introduction of new exhibits across the museum system, the degree of the sharing of artefacts and perhaps the ability to provide remote access to some content which is then integrated into more distributed presentations could all offer the local community leaders the opportunity to influence and spread the visitor loads and maximize the visitor satisfaction with the venue and events.

The use of new generation GIS and the interoperability with other evolving, dynamic repositories of information will help planning much as the ICTs have helped with the management of traffic patterns and solid waste. In 10 years' time, there are likely to be many 'heritage departments' in all levels of government, but they are not likely to be primarily staffed by art historians or archaeologists alone. The recognition that material heritage is an (endangered) part of the biosphere is going to spark a recognition that it must be managed and conserved, not just rebuilt and decorated for special events. For even if the crowds do come, what happens when the event is over?

On the community level, the shift is expected to be towards long-range heritage management rather than specific event- or tourism-related promotion. This scenario is therefore exceptional in that an influx for a specific event is being planned, but the important aspect is that the situation can be accommodated and investment planning is enabled because of the continuing planning and impact assessment tools.

The use of the major event (not at all envisaged as a heritage major event) was to demonstrate the inevitability of the situation where a step change in visitor numbers can give rise to political concern over whether the existing infrastructure would be able to cope. Hence the situation engenders the political will to actually engage in a more holistic view of planning the heritage assets of the whole area, rather than isolated and individual sites. Technology can be crucial in creating models of likely impact of changing economic conditions, population, zoning, etc. Heritage is not just an exploitable resource, it is non-renewable and structures and tools must be created for its effective management.

The intent of the scenario is to consider how to engineer a better distribution of the visitor flow to the more minor sites, which often have much to offer, in order to relieve the pressure on the main sites. After the event the impact of properly orchestrated systems for visitor management would continue to help manage the heritage assets.

The scenario is obviously based on current issues for the City of London. In a July 2006 press announcement UK Culture Secretary Tessa Jowell cited the 2012 Olympics as a "unique opportunity' for tourism, and linked it directly with cultural heritage management issues as she launched the widest ever consultation of the industry:

> "It [the consultation] suggests options for fully exploiting the benefits of the Olympics including: (…) New links between tourism and the arts, media, and all other sectors which will contribute to making 2012 a success. This could include specially themed marketing in the run-up to the Games, highlighting individual aspects of what the UK has to offer – including culture, heritage, landscape and diversity" (DCMS 2006a).

It is clear that such events will generate increasing opportunity to link regional cultural heritage assets to a managed plan for handling the influx of visitors. In fact an event such as the World Cup offers potentially better prospects than an Olympic Games with more separation between local events and the restricted capacity and appeal of individual events relative to the overall volume of visitors, meaning that a significant proportion will be at a loose end on a more regular basis during the tournament.

This scenario therefore highlights the needs for:

- Models for assessing socio-economic impact of sites, including the return on investment, likely visitor patterns etc. where new developments are planned for existing venues;
- Integrated information systems allowing assessment of visitor patterns and motivations;
- Integrated views of the heritage resources of the region;
- Presentation technologies that create sufficiently entertaining and engaging experiences as to influence the visitors' choice of heritage venues to visit.

5.4.3 Overview of specific technologies/applications and processes implied in Scenario 4

Technologies/applications	Details of applications and processes
Integrated CH management system	Modelling and analysis of regional visitor demand and visitor patterns Holistic integration of regional CH assets in event planning and management Provision of up-to-date information in visitor centres and through mobile information Traffic control, routing systems, access control systems, etc.
GIS technologies	Real-time, dynamic representation of visitor patterns Interoperability with other evolving, dynamic repositories of information
Mobile location-based information services	For visitor information and routing (e.g., market local attractions, direct visitors to alternative sites, etc.)
Multi-lingual data processing	W.r.t. mobile information services, real-time sharing of experiences in different countries

Cultural story telling technologies	Development of story-lines Identification of most appropriate artefacts in special collections Distributed sharing of artefacts Virtual assembly of story lines and artefacts
Networked, real-time sharing of cultural experiences in different countries (e.g., Interactive TV)	W.r.t. to sport & culture programme during World Cup
Large-scale immersive displays	In large CH centres and football stadiums
Novel interaction technologies	Real-time staging of sport and culture events – e.g., interactive TV: different viewing angles, multi-lingual information, etc
Socio-economic impact analysis	Impact assessment tools, calculation of residual value of technological investments for CH experiences, etc.

Table 5.4: Overview of specific technologies/applications and processes implied in Scenario 4

5.5 Scenario 5: Environmentally endangered sites: A large-scale industrial heritage site

5.5.1 Scenario – story

Marek Wankiewicz is looking forward to the official opening to the public of an industrial heritage site, after several years of development, in a country of the former Soviet bloc. Besides considerable investments from the region, European Union funding has been a great help in sustaining the efforts to realize a multi-functional site. The site now accommodates a community and visitor centre, exhibition spaces, a social history research institute and an environmental information agency.

The mission of the site is to narrate in a multi-faceted way the socio-economic, cultural and environmental history of the former chemical and textile factories, the origin of which date back to the beginning of the 19th century.

The environmental agency is a data centre that wants to raise awareness and understanding of the importance of sustainable development for the region's future. The long-term negative environmental impact of the former factories is used as one demonstrator for this need. Moreover, the agency agenda includes monitoring the effect of climatic changes and the planning of measures to reduce pollution on the regional level.

The agency has implemented a network of monitoring stations in several areas of the region, amongst which is a historic market-town on the banks of the same river that passes the industrial site and located about 20 kilometres downstream. The traditional buildings of this town include a fine medieval town hall with particularly fine statuary. However, this suffers from the combination of aerially-borne deposits of pollutants as well as acidic rain and is part of a national programme to preserve such market-towns in the region.

Environmental monitoring data are captured by the sensor networks and sent to the environmental agency, where the data is processed, analysed and presented through GIS technology on Web-based maps as well as information displays in the visitor information centre. At the same time the condition of the stonework is closely monitored over time using highly accurate and detailed 3D scanning to detect small-scale degradation of the stone surfaces, which is cross-correlated with the environmental data.

The social history research institute investigates and interprets the history of the former industrial complex and contrasts it to life in the medieval town, its organizational and technical development, workers' social and cultural life, etc. As large parts of the factory archives have been lost, much of historical reconstruction builds on documents and recollections from workers' families.

Students of industrial archaeology also reconstruct machines and instruments using modelling and animation technology. The results are presented through virtual reality hologrammatic image and sound projection technologies in several halls of the factories interwoven with the stories recollected by the workers.

The researchers also track down the geographic spread and usage of the products that were produced by the factories and others that were typical of life in the medieval town. Missing artefacts, in particular, products of the factories, such as specimen articles made from textiles woven there, are searched out and added to the collection, making use of databases worldwide in locating them. At the same time artefacts that typify the past of the medieval town are also tracked down.

The researchers weave the site's industrial record and stories about the preserved artefacts into the historic narrative of the region and its changing environment. One important element of the semantic backbone of this narrative is an extension of the CIDOC Conceptual Reference Model for industrial heritage management. This extension is collaboratively developed and used by a network of industrial heritage sites.

5.5.2 Commentary and implications

Industrial heritage is threatened all over the world. The risk of loss through destruction and abandonment is enormous. Among this rich heritage are plantations, mills, mines, forges, factories, workers' housing, warehouses, canals and bridges, harbour buildings and areas, and whole industrial landscapes. Moreover, as Michael Nevell writes: "Today roughly 30% of all professional archaeology done in Britain examines archaeological deposits that include material from the industrial period (however that is defined)" (Nevell 2006).

Louis Bergeron, Honorary President of the International Committee for the Conservation of the Industrial Heritage, writes:

> "Big industrial heritage sites are always at odds with their environment because of the consequences of the pollution. They are the kind of physical remains which are exposed to quick and radical decisions of demolition because of the kind of landscape they generated – which seems to be a symbol of a natural distress or of an historical failure" (Bergeron 1998).

Since the 1980s a number of industrial heritage sites have been included in the World Heritage List (at present the list includes 43 such sites). However, in general, the situation of most industrial heritage sites is problematic. This is due to the reasons identified by Bergeron as well as the enormous financial resources that are required to preserve larger industrial heritage sites and carry out adequate programmes of re-use, historic research and cultural enhancement (cf. Nizhny Tagil Charter for the Industrial Heritage 2003).

In Europe, industrial heritage in the former Soviet bloc is particularly endangered. For example, with respect to industrial sites in Riga (Latvia), Anita Antenišķe from the Faculty of Architecture and Urban Planning, Riga Technical University, writes:

> "One of the greatest challenges regarding conversion of industrial sites in Riga is the huge scale of those areas. The industries located in the city were seldom a result of local needs, they were a part of a larger economical system be it Russian Empire in the 19th century or Soviet Union in the 2nd half of the 20th century. Therefore it is not easy for the citizens to relate themselves to the industrial past" (Antenišķe 2006).

As illustrated in the above scenario, ICT can support the preservation and communication of industrial heritage in many ways. Of particular importance will be to integrate the site, its historic record and artefacts in a multi-faceted narrative. As emphasized in the scenario, this narrative should particularly also include the environmental and ecological dimension of an industrial heritage site.

This scenario is also a place-holder for wider concerns in the area of preservation of any heritage in adverse circumstances, typified by the needs to engage in clean-up work following periods of less than ideal industrial development. Whilst the scene is set in the former Soviet bloc, the situation could equally be represented by the extensive clean-up operations required as part of London's preparation for the Millennium celebrations.

There are two big issues here that will only get more frightening in the next 10 years: global climate change and the clean-up of industrial waste, particularly in the former Soviet Union and the developing world. One of the ICOMOS Scientific Council's most interesting initiatives is the Global Climate Change Initiative. We know so little about the effect of climate change on various fabrics and materials – and there is little monitoring of any but the most exceptional sites, such as Venice. It is also likely that a serious effort will have to be made to document vanishing resources, for example in the polar regions (cf. ICOMOS Polar Heritage Committee, http://www.polarheritage.com). What should be done in that case, where unique frozen tombs are melting? Or what about a scenario where environmental clean-up workers have uncovered archaeological remains at a toxic waste dump? What can be done to preserve these resources and clean up the site? How can the linked technologies of environmental and heritage monitoring be effectively applied?

Table 5.5 highlights the range of technologies already implied in the scenario presented. The broader category of working situations that this scenario represents will imply additional technologies and processes that could have been included in similar situations.

This scenario therefore highlights the need for:

– Accurate technologies for documenting the state of architectural heritage and analysing the changes over time;
– Search facilities for distributed collections and other sources for locating missing artefacts;
– Recreation/simulation of mechanisms from industrial heritage and the context of their use;
– Restoration systems including potential modelling of environmental processes and digital restoration simulations as well as physical systems for material clean-up and preservation of polluted materials.

5.5.3 Overview of specific technologies/applications and processes implied in Scenario 5

Technologies / applications	Details of applications and processes
Distributed wireless sensor networks	Monitoring climatic changes and the effect of pollutants and atmospheric factors on buildings of a historic village
Heritage monitoring data	e.g., humidity, erosion, material decay, etc.
Software for processing, analysing and presenting heritage monitoring data	e.g., novel visualization methods for the impact of pollution on materials used for historic buildings in the region
Environmental impact modelling and simulation	Models for assessing the long-term environmental impact of an industrial site
GIS technology	Web-based maps (GIS), information displays in a visitor information centre
CAD and animation technology	e.g., for reconstructing the ways in which industrial machines and instruments were used
Virtual reality rendering and projection technologies	e.g., 3D projection technologies for the working of animated historic machines
Multi-faceted historic narrative	Applications should support different 'lenses' on, and paths through, historic records and narratives
CIDOC Conceptual Reference Model – extension and adaptation for industrial heritage	Ontology development guidelines, preparation and implementation tools (note: there is a need for more effective tools for preparing the adaptation and implementation of the CIDOC-CRM, as has become evident, for example, in the adaptation of the CIDOC-CRM for English Heritage's Centre for Archaeology (cf. Cripps et al. 2004)
Industrial heritage resources management	Applications should support integrated approaches of CH resources management

Table 5.5: Overview of specific technologies/applications and processes implied in Scenario 5

5.6 Drawing together the threads from the scenarios

5.6.1 Technology needs identified in the scenarios

In the previous sections we examined a number of scenarios, each of which was currently unachievable, even if appearing tantalizing close, based on the promise of demonstration systems and the claims of their implementers.

Some of the advances needed are generic to any application sector, and will change the Cultural Heritage Sector in the same generic ways as in other sectors. However, generic technologies can be made more effective in any individual sector by incorporating domain-specific knowledge to develop domain-specific tools and domain-specific business processes. In this Research Agenda we will concentrate on those parts of the required developments which are specific to the Cultural Heritage Sector and to the business processes required by memory institutions and cultural heritage professionals.

The five scenarios highlighted the needs for:
– Mobile access from geographically-remote, and probably environmentally-challenging, locations to remotely-located resources and expertise;
– Integrated, but distributed, cultural heritage resources including catalogues, digital records, digitized collections of all types of cultural heritage data and management of physical artefacts;

- Distributed expertise, informed by common views of the available information, requiring common knowledge extraction, collaborative environments and the presentation tools (hardware and software) with which to explore them;
- A variety of novel onsite data capture devices, capable of supplying different types of data and information to the collective and integrated enterprise;
- Systems for capturing, analysing and interrogating user-created content based on a variety of media including speech, storytelling, dance and music;
- Interactive systems for accessing a network of integrated resources and expertise from the home, based on technology convergence;
- Interfacing technologies enabling novice and non-specialist users to be creative with the resources, and assemble presentations drawing on and relating concepts from multiple sources. The range of functionality for these non-professional needs to be similar to that of the professionals' toolkits, but with intelligent interfaces requiring less manual intervention and assisting novice and non-specialist users, using built-in domain knowledge to allow them to meet their challenges;
- Presentation software and hardware technologies that create sufficiently entertaining and engaging experiences as to influence the visitors' choice of heritage venues to visit and/or that enhance the learning experience;
- Integration between e-learning environments and museum resources;
- Models for assessing socio-economic impacts of sites, including the return on investment, likely visitor patterns etc. where new developments are planned for existing venues;
- Integrated information systems allowing assessment of visitor patterns and motivations;
- Integrated views of the heritage resources in a region;
- Accurate technologies for documenting the state of architectural heritage and analysing the changes over time;
- Search facilities for distributed collections and other sources for locating missing artefacts; potential linkage to police and insurance systems;
- Restoration systems including potential modelling of environmental processes and digital restoration simulations as well as physical systems for material clean-up and preservation of polluted materials.

5.6.2 Grouping of the needs

These needs can be grouped into some broad areas which broadly represent different types of processing digital cultural data and the specific needs arising from using generic technologies effectively for cultural heritage applications as follows.

Data capture of many formats of data under a variety of conditions

- Onsite data capture;
- Capture of artefacts, monuments and architectural heritage;
- 3D data capture;
- Documentation of 3D digital objects;
- Capture of user-created content;
- Intelligent data capture tools using domain-specific cultural heritage knowledge including provenance and other metadata;
- Digitization and enhancement of legacy metadata.

Search and research: Semantic and multilingual processing

- Ontologies, taxonomies and thesauri;
- Multi-lingual and multi-cultural knowledge bases;
- Digital memories for cultural information integration;
- Reconstruction and simulation;
- Knowledge discovery (or 'excavation in the digital domain').

Visualization and presentation

- Asset management;
- Development and deployment systems for Augmented Reality interpretations used with replica and/or original artefacts;

– Authoring tools tailored to cultural heritage presentations, linked to digital cultural heritage assets embedded in a digital context;
– Authorship tools for cross-platform and multi-platform interactive systems (e.g., delivery via iTV, computer games machines and other domestic-level technologies, Internet and location-based immersive VR/AR systems in memory institution visitor venues);
– Tools and techniques to allow presentation of provenance, paradata (cf. London Charter), interpretation and uncertainty;
– Adaptation and adoption of novel interaction techniques for domain-specific applications (e.g., storytelling with multi-lingual, speech-enabled avatars accessing domain-specific knowledge);
– Frameworks for authorship of multi-cultural, multi-national, and multi-lingual presentations and multi-faceted interpretations;
– Understanding and measures of engagement to inform authorship tools.

Mobile, distributed, and networked systems
– Many (some would argue mainly) generic technologies;
– Specific issues with design of system architectures suitable for integration in broader CH professionals' business processes;
– Cultural heritage component in design/implementation of CH-specific components for cross-platform systems;
– Integration and interoperability of data, coupled with the implementation of rich functionality which implements effectively CH requirements (e.g., recording of excavation data: contexts; artefact scans; images; textual descriptions; positional information; etc.) on less capable hardware (e.g., next generation PDAs);
– Standards for cross-referencing and sharing cultural heritage data with remote sources;
– Maintaining and extending associated provenance etc. whilst extending the information base;
– Interoperability with generic cross-platform applications (e.g., appropriate GIS systems).

Long-term availability (requiring long-term preservation and attention to issues of upwards compatibility)
– Formats (standards, encodings, metadata, provenance, paradata);
– Business processes for long-term preservation (media, regimes, security, resilience, redundancy);
– Legal frameworks (IPR, copyright, licensing, royalties, grey literature/documentation, metadata rights, collected works, derivative works, orphaned works, etc.);
– Business models for long-term preservation (responsible authorities, legislative requirements, secure financial basis, etc).

In the chapters that follow the key research topics of these lists are further elaborated with descriptions of the current state of the art and challenges anticipated in the short, medium and longer terms.

5.6.3 Current state of the art and research challenges

The areas requiring further work fall into a number of distinct categories:
(1) Measures to achieve integration of the current partial technologies;
(2) Issues of deployment – achieving a critical mass of available data, expertise and adoption of the technologies;
(3) Incremental improvements of current technologies;
(4) Fundamental research to develop new tools to achieve the more imaginative and intelligent functionality.

These different perspectives are apparent in both the timescales for addressing the foreseeable issues and the nature of the work to be undertaken. The specific actions required to address integration issues include identification, adoption, deployment and further development of appropriate standards. Interoperability obviously requires that a range of compatible standards underpin all areas of developing technologies to ensure inter-operability of data and support systems. To avoid duplication of the discussion the standards discussion is treated separately.

The challenges of deployment also span all areas of effective development of future technologies for cultural heritage applications. Put simply – unless and until a critical mass of the raw materials and systems that support the cultural heritage profession(s) are available in compatible systems that offer added value to the delivery of their professional duties, new developments will remain prototype demonstrations.

However, it takes significant time to develop the more advanced tools envisaged and to produce the critical mass of data in interoperable formats. During this period it would be appropriate to be developing the professional environment so that in parallel to the creation of integrated data environments, the skill sets and business models suitable to exploit their potential are also developed.

Since the measures required will be equally applicable to the introduction of technologies in all aspects of cultural heritage activity, separate consideration is also given to the business support aspects of preparing and encouraging development of the sector for the inevitable changes that will accompany the introduction of extensive, embedded use of technology.

One aspect of this period of ramping up the volume of available digital cultural heritage assets will be that the extensive period required to digitize legacy data will make it probable that the 'ideal' format for encoding cultural heritage information will also develop. In these circumstances it is important to anticipate that even data that is being newly digitized at the moment will require further development in the future – almost as if it becomes legacy data before a widespread compatible infrastructure and associated critical mass of data is completed. It is consequently likely that significant effort will be needed in the future to produce tools to assist in adding more material to early digitized datasets. The exact nature of these tools will depend on developments in the standards and systems over the next few years, and so the likely nature of these is difficult or impossible to predict at this stage. We therefore will not consider these aspects further here.

6 Technological research topics and priorities

In the scenario work described in the previous chapter a number of relevant research topics for future cultural heritage ICT applications have been identified, of which some are considered as key topics. The selection of these topics was discussed and consolidated in successive Research Agenda workshops. The following sections present these technological research topics and identify the current state-of-the-art and further research needs that are considered as priorities for progress towards enhanced and new capabilities of cultural heritage ICT applications.

6.1 Data capture

The list of research topics under this heading in section 5.6.2 comprises: Onsite data capture including metadata, artefact/collection digitization including metadata, digitization and enhancement of legacy metadata, and intelligent data capture tools using domain-specific cultural heritage knowledge including provenance and other metadata.

Each of the situations represented in the list of required research includes reference to the need to record metadata. This is intended to reinforce the message that digitization of raw data (e.g., describing the shape and colour of an artefact) must be accompanied by recording information to qualify that data and the process used to capture them. Additional metadata will, of course, be added as more research is undertaken with subsequent analysis of whatever class of raw information is being recorded. This can vary from recording a context and later relating it to other contexts to adding subsequent results of analysis in laboratories or archives. We refer to the trail of recording such processing and the decision-making processes associated with it as the digital 'provenance' (some professionals have also referred to this as the 'empirical provenance'), and where the word 'provenance' is used in this document it is intended to refer to the digital provenance. The more usual provenance of historic artefacts (the documented history and record of transfers etc.) for the purposes of this document are treated as elements of the metadata.

The capture of digital representations of cultural artefacts and environments is almost always related to a specific use. It is therefore appropriate to try to distinguish categories of use that give rise to different requirements and obligations. Three might be distinguished as digital surrogate, visualization, and representations captured for illustration or entertainment. The digital surrogate is the closest fidelity to the actual object that can be achieved digitally and theoretical representations for other purposes might be extracted from the surrogate. However, in practice it is unlikely that such levels of detail will be justified or achievable over all cultural artefacts and other categories may well be sufficient for identification or to get an impression in a Web page. The dangers arise if a representation is used out of the context for which it was produced. The concerns here are inevitable and could impact on the willingness of some cultural heritage professionals to allow digital models to be produced and used. However, the solutions lie in the careful use of provenance information and in defining ethical standards and business processes for the creation and use of the digital models. In this agenda we assume that processes are targeted at the highest quality but that the choice may be made not to digitize at that level. The suggested research is intended to enable the highest quality to be produced if an exercise demands it.

For the purposes of considering the types of data capture here the issues of the capture of the raw information and the linkage to metadata will be considered separately.

6.1.1 Activities and processes in onsite data capture

There is a requirement for better support of field data collection which comprises the planning of field surveys and excavations, and the processing and structural analysis of finds data, resulting in archiving and publication of research results.

The following *processes* can be identified:

- *Planning*: This will typically involve accessing previously collected data and preparation of surveys and excavations based on known field data sources (e.g., literature, archival sources, databases and GIS data). Generally, also issues of project strategy and project management need to be taken into account. There is thus a direct connection between the ability to link dispersed sources of prior information and planning of further work in the field.
- *Field survey*: This includes all data from the landscape such as topographic features, standing buildings, visible remains, field walking (intensive, extensive), documentation of geology and soils as well as geophysical aspects.

- *Excavation*: This includes all data from the site such as textual documentation and numeric data, topographical and stratigraphical data, photography, and 3D data capture.
- *Finds processing*: This includes processes of identification, classification, drawing (for archive and publication), and weighing and counting, all typically carried out by specialists (note: there exists a particularly extensive literature on statistical analysis of artefact assemblages). Note that although field scanning of artefacts is potentially possible it is likely that, in terms of detailed recording of individual artefacts, the results will be improved by scanning under controlled conditions in the laboratory at a later date. In this case the onsite scanning will be useful for recording the find's location in context and relative to other finds.
- *Structural analysis*: A particular research challenge here is to proceed from topographic and stratigraphic data to an understanding of land use through time. A basic approach is grouping of Stratigraphic Units, features, structures, building groups, and temporal groups.
- *Archive and publication:* This represents the final stage of the data collection process, and the start of data and collection management; and communicating the results to other cultural heritage professionals.

The word 'tools' is used in a variety of contexts when describing onsite data collection. These range from individual instruments used for recording specific data elements (e.g., levels, magnetic field or photographs) to integrated systems of recording using particular operational protocols, standardized forms etc.

The development of effective integrated recording systems for field data collection has been hampered by the tendency of many researchers to want to develop their own complete packages, which may include one or two innovative features, but to a large degree replicate facilities in existing packages.

There are many separate tools for different tasks involved in 'conventional' recording. Hence, there is a need for a higher degree of integration of tools. This would be achieved most effectively by defining a common modular framework for integration – common interfaces to tools and common formats for the data they produce. The objectives will not be served by creating monolithic systems. For example, a closer integration of surveying and geophysical instruments would be beneficial. However, the generation of a common modular framework is hindered because some producers of the better, extensible, tools have yet to be convinced of the advantages of publishing their API, encouraging others to continue to reinvent.

For deployment there are a number issues concerned with spreading more standardized working methods and resources – some relating to insufficient availability of tools based on agreed standards (e.g., CIDOC – Core Data Standard) and some to standardized and agreed working practices. Regarding mobile tools, the existing research questions are mainly methodological, not technical (though some developments are hampered by poor OTS technology).

Unfortunately, there exists a widespread ignorance of standards (e.g., CIDOC CDS) and for data standards, proprietary GIS and CAD de facto standards are in wider use. With respect to guidelines on working practices some consolidation can be observed, e.g., in the UK there exists a widespread use of recording forms based on the Museum of London Archaeology Service Manual (MoLAS 1994).

- There are a number of research issues relating to these tools and to the tasks listed above. For example:
- Linking field survey planning to existing data sources would be a potential research topic for improving search functionality as well as an infrastructure development need; issues here range from definition of compatible datasets, deployment to include a critical mass of historic sources and provision of search tools with a range of increasing sophistication. Research here ranges from incremental advance to potential fundamental advance;
- Completing the considerable missing links in the driver architecture for survey instruments to improve integration of resources;
- Further standardization of data formats captured during excavations is required, e.g., there are considerable development issues with respect to giving structure to text and numeric data (i.e., the semantics of the information and numeric data organization);
- In general, the CIDOC-CDS should be more widely incorporated via the use of recording tools which encode the data captured in the appropriate form;
- Structural analysis could benefit from the integration of different scale data as well as easy availability of older survey data for comparison;
- 3D data capture technologies have yet to demonstrate a clear value to the excavation process on many site types, but the potential might emerge only as other technologies become used more widely and those using them become more technologically aware. The longer-term challenges most commonly relate to intelligent

instruments incorporating knowledge of their working environment – for example, recognize object classes and adapt their modus operandi to optimally handle them.

3D techniques are most likely to be of advantage in documenting monuments and standing architectures, although one could conceive of intelligent recognition of partially uncovered finds, and it is these areas that we consider next.

6.1.2 Different circumstances in the digitization of cultural heritage objects

The digital capture of artefacts covers a very wide range of situations. The following different circumstances may be particularly important to recognize:

- Digitization of collection catalogues, including library catalogues: This is one of the earliest forms of digitization for memory institutions. The original problem is to make legacy catalogues available in a digital format in conventional databases and most major memory institutions will have completed digitization of at least aspects of their major collections' descriptions. However, issues remain concerning the format and content of such catalogues, which may be uneven with many national standard formats and other variations depending upon the language used and its character set. Current challenges concern standardization of formats, perhaps requiring additional metadata, conversion tools and cross-lingual and multi-lingual search.
- Image-based digitization (digital version of historic processes to move documents onto microfilm/microfiche) concerns the digitization of images of text works. Frequently these are later processed via OCR technologies to produce full text digitizations.
- Full text digitizations of written works allow all sorts of semantic and linguistic analysis, and producing them is commonly viewed as a solved problem. However, evidence from the experiences of digitization centres suggest that there are remaining issues concerning primarily earlier font designs, with Gothic fonts before about 1840 specifically cited as presenting serious problems for a significant body of historic texts, particularly in German. Other problems concern texts in languages using characters beyond the standard English set and natural language processing in other languages. At the simplest level additional accents and diacritics complicate the character recognition, but more complex issues can arise concerning extracting the semantics in different languages.
- An additional level of complexity arises where the individual objects are older; these may be illuminated manuscripts, incunabula and other early printed works. Considerable expertise in digitizing this material is available in the digitization departments for some European National Libraries.
- Considerable complications are known to arise with carved inscriptions, including hieroglyphics for example. In this case the artefact is clearly 3D but includes identifiable semantic information comparable to more conventional text objects. Figure 6.1 shows some examples of essentially text objects included in the context of 3D artefacts.

Figure 6.1: (a) Spreadsheet apparently carved in Stone; (b) Hieroglyphic carving at varying degrees of relief around curved pillars

In this category there are also significant issues of handling fragments of unique texts and of drawing inference from multiple partial copies of the duplicated texts (e.g., the USA Declaration of Independence or the Waitangi Treaty in New Zealand). Digitization of documents in this category might well require more complex methods (e.g., multi-spectral scanning) and high levels of accuracy, including potential digitization of details of surface indentation. Where handwritten manuscripts are involved there is the potential for the additional complication of recording alterations not just initially but over time (Twycross 2006).

- Predominantly 2D objects – images: This category concerns the digitization of genuinely 2D artefacts, which are predominantly photographs (since paintings and drawings have rather different characteristics, described below). Collections of historic images are commonplace and a great deal of work has already been undertaken on defining appropriate formats. The issues here concern the need to digitize the vast numbers of images before they degrade; issues of restoration; the rapid improvements in available digitization accuracy; and the evolving good practice in encoding associated metadata, provenance etc. Although an increasing proportion of images are being 'born digital' different issues arise, including those of provenance noted above and the increasing need for curatorial skills in determining which images do not need to be archived.
- Paintings and drawings present a variation of digitization of images having the additional features of methods of creating the images and, of course, the well-known use of techniques such as X-ray to show underlying structure and layers of paint. Drawings have similar properties but also include the potential to be representations of higher dimension objects (e.g., engineering drawings or architectural plans). Digitization in these cases might include much more information about the objects represented and about the way in which the drawings were derived (sections, plans, perspectives, dimensions etc.).
- Moving image digitization involves a separate set of issues including data volume (compression techniques) and mass digitization needs to be undertaken in order to provide long-term archive of the enormous quantities of material originally recorded on fragile media. Estimates indicate that around 100M hours of AV material including video, film and sound from the 20th century are awaiting digitization. Given the rate of decay of the historic material this exercise is extremely urgent. The FP6 project PRESTOSPACE was targeted at this issue. Once digitized and placed in a long-term archival protocol to ensure preservation there remain significant research challenges in areas such as information extraction from the digitized content – for example, analysing the material for particular content (places, people, events etc.) or automatic shot cataloguing.
- 3D artefacts are another class of object requiring specific technologies for massive digitization. There are wide variations depending upon the scale of the objects being scanned from whole archaeological sites to individual items of micro carving. Challenges range from the opportunity (or not) to capture the objects under controlled lighting conditions, issues of scale etc. We shall examine digitization issues for these classes of data below.

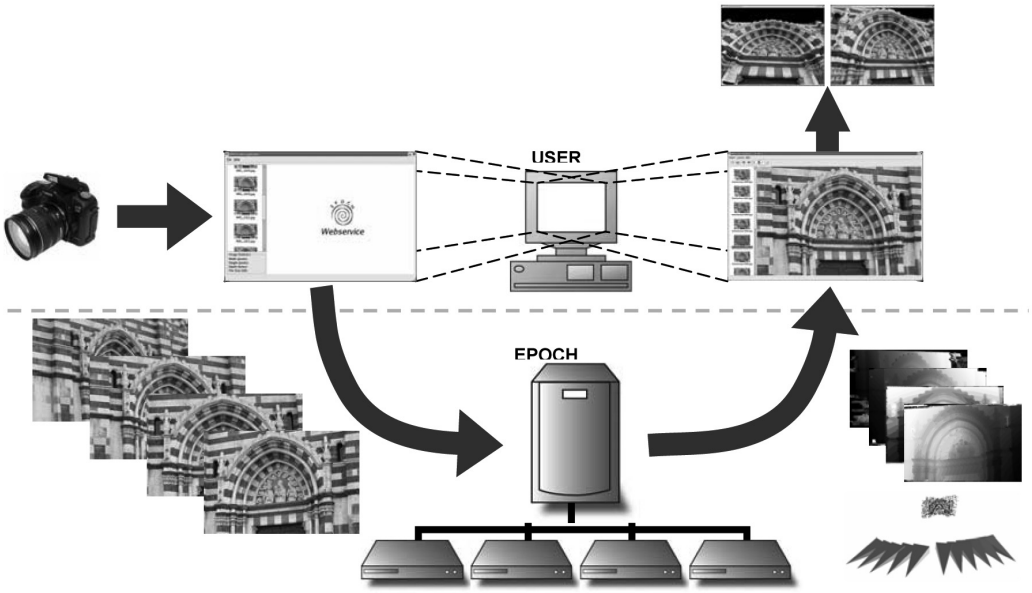


Figure 6.2: 3D from a series of images using the EPOCH 3D Web service developed by Van Gool et al (KUL, Leuven) (Vergauwen and Van Gool, 2006)

– 4D objects are not commonplace but might arise for example with the animation of 3D objects for cultural heritage.
– Structural representation (with linkages to component descriptions) also require capture, though this would not typically be digitized directly, but assembled with manual intervention by the archivist or other cultural heritage professionals.

The different challenges represented by this wide range of data types means that each can be regarded as a distinct area of expertise, requiring distinct regimes of good practice and recording devices and it is true that devices have been purpose-built for many of the situations. There are many different Ftechnologies and in general similar technologies may be used for different environments. The technologies can be grouped according to the dimensionality of the artefacts being captured.

Most of the outstanding issues relating to 1D and 2D capture – excluding interpretation and retrieval – relate to procedures for capturing and modifying metadata to produce integrated resources and to the sheer volume of material that is in need of digitization. The techniques and technologies for acquiring the required digital representations have become sufficiently routine to regard further work as deployment and development rather than research. We will therefore concentrate in the next section on the issues, state of the art and future actions required for 3D artefacts.

Figure 6.3: The Digital Michelangelo Project, Stanford University

6.1.3 3D data capture

The last few years have seen much development in 3D applications for cultural heritage purposes (for example, compare the overviews of Addison 2000 and Beraldin et al. 2005a, Beraldin et al. 2005b). However, there remain considerable limitations to effective digitization of 3D objects and to their use in applications in cultural heritage.

3D objects are an important part of digital cultural heritage, because perceived reality is in 3D with change over time frequently regarded as the fourth dimension, i.e., changes to heritage buildings, landscapes, etc. due to environmental effects and human activity, development, war, changes in land use driven by economic demand, etc.

In practical terms, for 3D objects the following processes need more effective support:

3D acquisition: The only way of substantially reducing the time, effort and costs of 3D acquisition in the long term is to create intelligent tools which will simplify the processes and reduced the level of ICT skills needed to undertake the tasks. This will be done by developing methods and tools which allow the operator to undertake the tasks based on working practices in the application domain, rather than becoming an ICT expert in order to be able to operate tools that intrinsically feel alien to them. For example in 3D-scanning and photogrammetry, a core problem in 3D data manipulation is at present that of merging multiple raw scans and smoothing. This is undoubtedly difficult operationally, but the development of tools that make this operation semi-automatic and user-friendly offers a more sustainable approach than to alter the working practices and educational background of all cultural heritage professionals to accommodate these processes.

Documentation: Importance of becoming much clearer about the place and role of 3D objects in digital libraries; how can we achieve a deep integration of 3D in digital libraries? Of importance here is the conceptual integration into the world of documentation standards. These aspects also overlap with concerns for long-term archival formats and are dealt with in the section on standards (Chapter 7).

Visualization and reconstruction: The ‘simple’ issue here is to remember the history of a reconstruction (c.f. version control). However, this simple view is somewhat compounded by the process of reconstruction (interpretations, derived works and assemblages), where the basis of decision-making and the evidence on which those choices are made may also need documenting and carrying forward with the digital artefacts.

Display/presentation: There is a need to support a variety of display purposes such as scholarly research and public presentations (e.g., museum exhibitions) through 3D CH representations. These different purposes need to

be sensitive to different requirements in terms of the balance between explanation and educational motivations and engagement and entertainment objectives. The balance needs to preserve the credibility of what is shown even where the objectives may be less educational and more entertainment orientated.

6.1.3.1 Requirements of cultural heritage 3D acquisition

There is a wealth of 3D acquisition techniques. EPOCH Deliverable D3.1.1, section 6.1 (EPOCH, D3.1.1, 2005) gives an overview, discussing the general pros and cons from a cultural heritage perspective, and listing the issues CH professionals may want to pay particular attention to when choosing a particular technology. Thus, rather than repeat such an overview here, we simply reiterate our way of structuring the major technological 3D acquisition families (Figure 6.3).

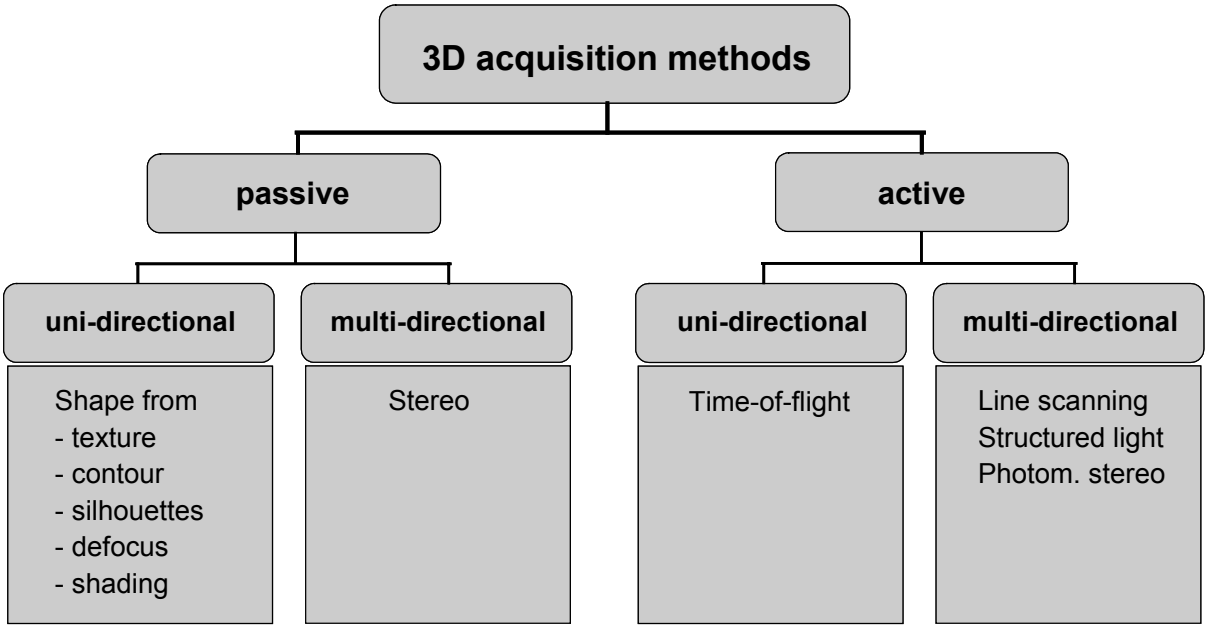


Figure 6.4: Taxonomy of approaches to 3D data capture

The first distinction that is made is between active and passive techniques. The former make use of special illumination, whereas the latter do not (i.e., they work with normal, ambient light).

Within each class a further distinction can be made between uni-directional and multi-directional, depending on the use of a single or multiple vantage points, respectively.

The bottom-line is that there currently are three technologies that dominate the market:

1. Photogrammetric methods, based on multiple images – passive, multi-directional;
2. Structured light and laser scanners – active, multi-directional;
3. Time-of-flight methods – active, unidirectional.

The 3D capture and modelling of cultural artefacts is a challenging task. As a matter of fact, the particular combination of demands from the field of cultural heritage turn it into one of the most critical testing grounds for 3D capturing technology. Claims that 3D scanning is a solved problem therefore are premature in this area. Simple adaptations of existing technologies will not suffice to offer adequate solutions. Here is an overview of some of those challenges:

1. Adverse working conditions: For many applications, the equipment has to be brought on-site. This can mean bringing it to remote excavation sites, in a desert or a rainforest.

2. Hands-off conditions: Museum exhibits are often too fragile or valuable to be touched. The scanner should be moved around the object without touching it. Systems that are portable are to be preferred.

3. Intricate shapes: Many important pieces of art have intricate shapes. Scanning these requires great precision to be combined with agreat agility of the scanner. It has to capture narrow cavities and protrusions, and deal with self-occlusions, fine carvings, etc.

4. Low price: The area of cultural heritage may have a huge intrinsic value, much of which can be expressed in economic terms, but this usually appears elsewhere in the system (in hotels, restaurants, etc.) and not so much at the excavations or sites discovering or safeguarding it. In addition, even when caring for priceless treasures this does not equate to an automatic revenue stream or available capital for investment. In practice, within memory institutions, the money that can be spent is usually very limited. Hence, solutions typically have to be cheaper than those affordable by industry, where the benefits may have a commercial return on the investment.

5. Diversity of materials: The types of objects and materials that are to be handled are very diverse. They range from metal coins through woven textiles, stone or wooden sculptures to gems and glass in jewellery. No single method can deal with all these surface types at once.

6. Speed: Museum collections are often huge. Excavations tend to produce an enormous number of finds. Even 3D modelling the most important and representative part means producing models for thousands of objects. Speed is of the essence to render such endeavour practical.

7. Size range: Things to scan range from tiny objects like a needle to entire an landscape containing petroglyphs.

8. Non-technical users: The users of the equipment usually did not have technical training. This stands in sharp contrast to the use of similar equipment in industry.

9. Lack of predefined specifications: Precision is something of a moving target in cultural heritage. There is often a type of analysis that would also become possible if even more precision could be obtained.

6.1.3.2 Technological research issues in 3D capture

The previous considerations lead to a number of desirable, technological developments.

1. *Combined extraction of shape and surface reflectance:* 3D scanning technology is already being aimed increasingly at also extracting high-quality surface reflectance information. Yet there still is some way to go before high-precision geometry can be combined with detailed surface characteristics like full-fledged BRD (Bidirectional Reflectance Distribution) or BTF (Bidirectional Texture Function) information.

2. *In-hand scanning:* The first truly portable scanning systems are already around. But the choice is still restricted, especially when surface reflectance information is also required and when the method should work with all types of materials, including metals and gem stones.

3. *On-line scanning:* The physical action of scanning and the actual processing of the data are often still two separate steps. This may create problems in that the completeness and quality of the data can only be inspected after the scanning session is over. This is the equivalent of creating scanned images of text and subsequently processing the images using OCR to create the full text version. By then it may be too late or cumbersome to take corrective actions, such as taking a few additional scans. For 3D digitization, for example, it would be very desirable if the system would extract the 3D data on-the-fly, which would give immediate visual feedback. This should ideally include steps like the integration and remeshing of partial scans.

4. *Opportunistic scanning:* There is no single 3D acquisition technique currently able to produce 3D models of even a large majority of exhibits in a typical museum. The techniques sometimes have complementary strengths and weaknesses. Untextured surfaces are a nightmare for passive techniques, but may be ideal for structured light approaches. Ideally, scanners would automatically adapt their strategy to the object at hand, based on characteristics like spectral reflectance, texture spatial frequency, surface smoothness, glossiness, etc. One strategy would be to build a single scanner that can switch strategy on-the-fly.

5. *Multi-modal scanning:* Scanning should not only combine geometry and visual characteristics. Additional features like non-visible wavelengths (UV, (N)IR) have to be captured, as well as haptic impressions, all of which currently would need separate instrumentation and scanning processes. Haptics would then also allow for a full replay to the public, where audiences can hold even the most precious objects virtually in their hands, and explore them with all their senses.

6. *Real-time, detailed 3D capture:* In the same vein as SLAM (Simultaneous Localization and Mapping) activities in robotics, there will be an increasing need to quickly build detailed 3D maps of complex and dynamic environments. Part of the task will be to estimate the lighting conditions. Once this is possible, virtual objects can be included into real environments for portable augmented reality applications, from free vantage points, and where the real can occlude the virtual and vice versa.

7. *Semantic 3D:* Computer vision is gradually reaching the point where scene-understanding becomes feasible. Objects and scene types can be recognized from 2D images. This will in turn have a drastic effect on the way in which low-level processes can be carried out. If high-level, semantic interpretations can be fed back into 'low'-level

processes like motion and depth extraction, these can benefit greatly. This strategy ties in with the opportunistic scanning idea. Recognizing what it is that is to be reconstructed in 3D (e.g., a house) can help a system to decide how best to go about the task, resulting in increased speed, robustness and accuracy. More on this is also to be found under the research agenda for procedural modelling.

8. Obviously, once 3D data have been acquired, further processing steps are typically needed. These entail challenges of their own. Improvements in automatic remeshing and decimation are definitely still possible. Also solving large 3D puzzles automatically, preferably exploiting broad shape characteristics in combination with surface detail and texture information, would be something in high demand in the cultural heritage domain. In addition, techniques to cope with shape matching and reconstruction of sets of pieces where some pieces are missing and all are normally worn, would represent a more typical case. This would be assisted by an understanding of the processes of ageing and wearing (see also later challenges in modelling).

Against the general backdrop of 3D data capture it is important to note that a series of recent techniques, generally referred to as image-based rendering, also hold good promise for cultural heritage. We consider these techniques to fall under the issue of combining (and balancing out against each other) the aspects of shape and surface reflectance and texture acquisition.

These technological challenges are further complicated by the need to develop solutions which are accepted in the cultural heritage professions. This implies ease of use with little technical training, provable accuracy and sensitivity to multiple potential interpretations and the need to demonstrate why particular solutions have been proposed. Furthermore, there is a more pressing requirement that solutions for cultural heritage should be cheaper than perhaps they are in more commercial sectors.

During the EPOCH Research Agenda workshop at VAST 2006 discussion also focused on the following questions:

- How should targets on incremental improvements be set (for example, in the context of FP6 the objective was propagated to ‘halve cost of digitization in 4 years’)? This issue is complex because in many ways improvements in quality and achievability are as important as speed and tend to offset any improvements in speed. More typically the results may be better, but achieved in comparable time. As techniques are developed which allow adequate accuracy, speed-up may become a more independent target, but evidence from other sectors suggests that improved quality and functionality tend to attract more interest and attention than pure speed.
- Related to this the workshop perceived that precision is a moving target, not a given long-standing target, but one where the expectations change as the technical capability improves and applications learn how to exploit the accuracy (‘squeezing the max out’).
- How rapidly would ‘best practices’ change as equipment such as scanners improved? This issue addresses the question of deployment of technology and touches at least as much on moving the professions forward as on any explicit research into technologies. The underlying concern is that the technologies must demonstrate their worth before adoption in practice, but although this would be a necessary condition it would not be sufficient for the technology to be adopted and explicit sector development initiatives would need to be conducted in parallel.

The final concern was that it would be essential, particularly given the rate of change in technologies and the massive digitization exercises implied in many political agendas for developing the sector, that data would be recorded in many formats and by many techniques. Harmonization would also imply format conversion being applied over time so it would be essential that the provenance of digital artefacts was recorded and available. This provenance information needs to be secure during many format conversions and other manipulations and in this context the role of the ‘London Charter for the Use of 3D Visualization in the Research and Communication of cultural heritage’ should be emphasized (http://www.londoncharter.org).

6.2 Documentation of digital objects: Focus 3D objects

In this section we examine some of the research issues which take us, literally, beyond the surface- level data capture and representation of artefacts and into consideration of the semantics of the objects, sites etc – how we express, capture and encode our knowledge of their meaning. Since this deals with documentation it also inevitably leads us to discuss documentation standards and others that will enable the interchange of information and interoperability of services.

For the purpose of this discussion we consider 3D objects to be, in essence, documents which potentially encompass the full range of text- and non-text based data in a structured, integrated and cross-referenced digital object.

6.2.1 Short-term, urgent open research problems

In this section we describe some of the components of documenting 3D digital artefacts that require systematic research at the interface between computer scientists and professionals in the various cultural heritage domains. These issues should be manageable in the short term unless otherwise noted in the text. The objective of the research proposed here is to bring together the computer scientists' and CH professionals' understanding of the essential characteristics of these representations which influence the data collected on each and the semantic interpretation of the shapes. This will also influence the 'key characteristics' which is a notion used in determining long-term preservation strategies.

Define/classify relevant shape representations for CH:

Surfaces – Discrete: point clouds, surfels, range maps, triangle meshes, b-rep meshes, subdivision surfaces, primitives (spheres, cylinders, etc.); *parametric:* B-splines, NURBS; *implicit:* metaballs, moving least squares
Volumetric – Discrete: voxel grids, tetrahedral grids, octrees, BSP trees; *parametric:* trivariate splines, free-form deformations; *implicit:* F-rep, radial basis functions.
Structured – Articulated figures (bones), deformable models, procedural shapes, Boolean set operations (CSG), scene graphs, computer games, virtual worlds.

Define a sustainable 3D file format:

This entails defining: fundamental requirements for all 3D representations; a basic set of exemplary shape representations; a *customizable encoding* that can accommodate all attribute variations (vertex/face normals, etc), and a well-defined mechanism and process to extend the basic set in ways which continue to enable interoperability.

Generic, stable, and detailed 3D markup:

A method is required to reference a *portion* of a digital 3D artefact, irrespective of the particular *shape representation*, so that detailed surface and structural features can also be discriminated. The markup should survive simple editing operations (cutting, affine transformations) and be integrated with the paradata (as used in the context of the London Charter) which documents the digital artefact's provenance.

Define generic 3D query operations:

People are well acquainted with the search for images, for instance, as offered by Google or Ask. Yet, this search is currently still driven by the surrounding text and the image file names. The actual content of the images is not normally analysed, despite many attempts to design systems which undertake the analysis. For many CH applications, the direct access to the image content will be an absolute necessity, however. Queries will often be related to aspects that have to do with certain characteristics of the shapes of an object, of the ornamentation, etc. By their very nature these are not very well suited for textual description in any case. Currently, much progress is being made in the recognition of particular objects and instances of more general object classes. The key is to shift away from the traditional, global and very low-level features (colour histograms, moments, etc.) towards configurations of well-selected local regions that are characterized by certain levels of invariance to irrelevant geometric and photometric changes occurring under image projection. This said, it is clear that a lot of further investigation is still needed and CH will again be a particularly challenging field. Also, queries often probe aspects beyond the attention of the casual observer.

In the context of text-based search there are established constructs which are domain-based and define a known domain of discourse between the user and the knowledge base. The best known and understood is probably bibliographic search where operations such as searching for authors, publishers etc. are well understood and supported directly in the metadata. More recently other more complex searches, based on content, have become common place. For example searches on the basis of queries such as 'Find all the citations of this work by others' are increasing regarded as normal.

In qualitative research it is common to search for concepts in free text and analyse sources based on juxtaposition of these concepts and other information in the text. Currently this is done primarily by manual techniques, perhaps

assisted by coding assistance for the concepts defined in the context of individual investigations (e.g., Invivo). The next stages in the field of textual search will be to embed automated understanding of the language within the search tools, to enable higher-level conceptual search. Making this effective is a longer-term research target, with direct relevance to cultural heritage and requiring active engagement from professionals in each application domain.

In the context of 3D objects, research is substantially less well formulated and even the basic vocabularies for description and search operations require development. What sort of query methods should every shape representation be required to answer? What are the common concepts forming the base set of search operations? How would they be combined? (i.e., are traditional Boolean logic operators as applied to typical text search sufficiently rich?)

For example, a basic query method for a Bounding Box interrogation of a shape representation – Triangle Mesh – might return a list of triangles inside the box. This operates in the shape domain, which is already at a higher level than current search operators, but is still a long way off allowing the cultural heritage professional to undertake research based on the cultural heritage domain of discourse. Hence defining these elemental operations is considered a shorter-term research question.

An architect wishing to search for 'all surviving examples of timber framed buildings which were renovated and adapted to include Georgian facades' would currently be reliant on keywords attached to data rather than searches of the underlying objects. Such searches must be considered a long-term research challenge, and require a huge amount of prior research in defining the conceptual framework of codification and enquiry. The issues of enhancing metadata are considered further with the longer term issues below.

Provenance and processing history log

The provenance and processing of 3D digital objects needs to cover the initial data capture, the format and encoding of the individual elements and any refinements or abstractions that have been applied, documenting in each case the circumstances of the processing applied. If a processing history is complete then it is possible to envisage replaying the process of constructing the digital 3D object, perhaps varying some parameters in the process, or indeed substituting new or improved methods with later developments.

A significant issue in technology will be version control, not only of the digital artefacts or even of the tools used to process them, but particularly of the underlying technologies (computers, operating systems, compilers, and applications programmes) which have been used to construct them. Issues here will be minimized if properly independent file formats are used, but manipulations may still have produced differing effects where different machine architectures have been used, with issues such as numeric accuracy potentially becoming important as the underlying accuracy of digitization and processing arithmetic improves.

Two specific topics in the short term are therefore:

– A standard for describing the sources of digital 3D;
– A standard way of recording how the source data have been processed, and how they were combined to obtain the result.

On a very basic level we also need to apply unique identifiers (e.g., DOIs).

Maintaining consistent relation between shape ↔ meaning

Even at the level of shape representations derivation of a shape semantic is complicated by interaction with the specific inaccuracies of manufacture. For example:

– Given that architectural features will not be made with mathematic precision, is there such a thing as a circular arch in reality?
– Putting it technically, how can we relate a low-level primitive (a triangle) to the semantics of the overall shape?
– How can procedural 3D technologies help? (e.g., link a triangle from a scanned arch to a procedurally generated arch).

Ideally, we would be able to achieve full generative surface reconstruction, but some questions which arise are:

– Where and how is the link between shape and semantic stored?
– How can we author, query, and show that knowledge?

– How can knowledge and 3D information be kept consistent?
– How can we navigate through the semantic 3D graph or semantic associations represented?

At the technical level, in terms of current issues, questions such as 'What is the relation between METS, CIDOC-CRM, and Collada?' arise. In broader terms the relationship between ontological standards being used and further developed from a digital libraries perspective and the EDL emphasis on a digital library spanning a much wider spectrum of artefacts than the traditional text-based sources adds urgency to addressing these issues.

Although the immediate topics in this area may be considered and potentially solved in relatively short timescales, the challenge of achieving lasting standardization agreements may well mean that the search for agreement lasts more into the medium term. It is also likely that the topics will need continuing attention and the standards require maintenance as new levels of semantic representation become possible.

Other issues will arise during this process. For example, if we assume the meaning of a number of shapes is known in particular contexts and we then change that context, can we derive new meaning based on the context or does that require explicit re-coding? Similarly, if the shape itself is edited, at what point do we decide that the semantics have changed? Can we derive new meanings of shapes?

We might assume that the meaning of a shape is known and unambiguous, but of course this is not the case, as demonstrated by the current concerns of incidents with toy and replica firearms being wrongly interpreted and having life-threatening consequences. At a more relevant level in terms of 3D digital objects, the modelled version of a sci-fi weapon is designed to include many of the shape semantics of an actual firearm. In fact the designer typically relies on the shape's semantics to convey the threat and purpose of the object. It is therefore apparent that the semantic of shape exists within the context of other aspects of the 3D object and its environment, leading to questions of whether this context is an intrinsic part of the semantic or whether it is purely to resolve ambiguities.

6.2.2 Longer-term issues: Non-textual vocabularies and semantic 3D objects

For 3D digital objects adequate functionality for automation and integration is missing in a variety of areas, including:

– Structural representation (some of this is reflected in the previous section but the full functionality would need to take into account effects of aging, damage, etc. as a integral process in the life of an artefact);
– Content categorization/classification and analysis;
– Non-textual metadata for 3D objects, automated markup, and semantic enrichment;
– Indexing/searching (at higher levels) based on non-textual metadata, addressing the semantic content of the shapes and their constituent parts;
– Information extraction and abstraction;
– Search by similarity and type-based search.

These aspects are discussed below. It is important to address the research implied in these topics to get past the limitations which current data capture and encoding techniques place on what digital libraries can support with respect to 3D digital objects libraries. For example by exploiting the semantics of artefacts on users of such libraries would benefit from novel search and retrieval methods or semantics-based navigation through distributed 3D documents.

In the context of searching in 3D documents there are a number of underpinning areas of computer science in which these issues have already received some focused R&D. Successful approaches so far include: feature vectors, silhouette, depth maps, lightfield descriptors, volumetric abstractions: Sphere functions + 3D harmonics, shape distributions, statistical moments, shape spectrum, skeletal graphs, self-organizing maps (SOM), and others.

Among the more advanced European research initiatives in this field are the German Research Foundation's Strategic Initiative (V3D2); also the work carried out at the Visual Information Processing Lab of the University of Florence should be mentioned.

In the United States, the research group of the Princeton Computer Graphics Group led by Thomas Funkhouser merits mention, e.g., for their 3D Model Search Engine and parts-based 3D object classification approach (cf. Funkhouser, 2007).

The current development of metadata including the semantic Web approach is primarily text-based. However, an adequate (non-textual) vocabulary to characterize the content and structure of 3D objects in the sense described above is not available. Systems which provide some information that begins to address this area have been driven

by significant manual intervention. However, manual categorization of artefacts is extremely time consuming and could not have a significant impact on the enormous backlog of digitization, which includes:

- A backlog of undocumented artefacts (e.g., for London Museums 50% and more, according to Chris Batt, CEO UK Museums, Libraries and Archives Council, April 2004).
- A backlog of documented artefacts for which documentation is only available in paper-based systems.
- A large proportion of digitized artefacts for which the digitization has been considered a priority, but where the information so far recorded is partial and recorded using now outdated data technology.
- Even artefacts yet to be digitized where the potentially useful information is not yet recognized and routinely recorded ('future legacy data').

For typical library objects (e.g., text documents) nobody would use elementary pixel configurations to describe content and structure of pages. Instead, although scanning based on point data is the starting point, OCR is used and the content represented by characters and structural markup. There is, however, a continuum between objects whose primary interest is textual and those where the textual content is significant but other aspects become equally or more significant (e.g., illuminated manuscripts or inscriptions in stone).

If we scan a building (e.g., a cathedral) with a 3D laser scanner this typically will produce 10 million triangles or more, and the 'representation' of the artefact remains within the domain of (hierarchical) triangle meshes. The content and structure of this artefact at present is mainly described manually by textual augmentation; no high-level elements are available to represent content and structural markup in a domain-specific way and indeed systematic and inclusive vocabularies, taxonomies and ontologies have yet to be defined to underpin such descriptions.

Development of proper 'vocabularies' for a new generation of metadata capable of characterizing content and structure is key to 3D content categorization, indexing, searching, dissemination, and access. Humankind has traditionally adopted techniques which express our understanding of the higher dimensions in physical space by reference to lower dimensional representations to place order on higher dimensional structures. Thus 2D drawings (plans, elevations, sections and detailing) are used to organize and convey our understanding of 3D architectural constructions, plus an extensive set of conventional representations for drawings, features, labelling and indexing into structured data that can be systematically organized and searched in linear (1D) system.

Computer science has for decades sought ever improved ways of sorting and searching based on multi-dimensional organization and searching, exemplified by some of the higher-dimensional methods of organization of scenes in computer graphics (e.g., ray-classification schemes in ray-tracing). It is to be expected that techniques will be developed to allow higher-dimensional constructs of semantic information to be searched efficiently rather than the reduction of the search domain's dimensionality in ways which people might find an aid to simplifying the problem.

The important breakthroughs will need to be based on developing the understanding of the higher-dimension semantic relationships that we seek to understand and represent, many of which are intrinsic and subconscious in human understanding but not established, documented, shared consistently and agreed. Only when this work is tackled will we be able to overcome the current treatment of 3D objects in Digital Libraries as BLOBs (Binary Large Objects) and generalized documents.

The goal is a complete semantic 3D-model instead of projections in lower dimensions (image, section, animation, text) or structureless collections of polygons. What we need to achieve is a deep integration of 3D into digital libraries and collections management systems.

The benefits of such models can be assessed through a comparison with the traditional approach of representing 3D objects, which is based on (hierarchical) polygonal meshes. This approach implies the following problems: Loss of structure, content-based handling is (almost) impossible, inappropriate complexity measure (sphere: (centre, radius) is represented by a number of triangles which approaches infinity as the degree of required accuracy increases), data compression is very hard, no object-specific LOD (level of detail) representation is possible.

3D cultural heritage data which is semantically enhanced by incorporating knowledge from the cultural heritage domain is a field of research which lies at the core of bringing technological work and Arts and Humanities research much closer together. A great deal of research and development work is required and, in fact, this is fundamental to realizing the potential of technological support for Arts and Humanities studies, analysis and presentation. Moreover, cultural heritage management could benefit much from having available semantically-enhanced tools.

Before we can represent the semantic content of the 3D objects and assemblies of objects we must first define the vocabularies, taxonomies and ontologies that express the semantics and represent them. There are many studies of architectural, ceramics, decorative and other styles of man-made artefacts which document the variations in the

ways styles are adapted to different circumstances. There are rather fewer studies attempting to model the systems by which styles are put together or to express them in an analytic set of relationships which could be used as a template against which artefacts can be matched. Some of the work currently being undertaken in procedurally-based modelling is advancing the thinking in these directions (see below). Some of the components of this exercise are beginning to emerge.

A semantic gap between a shape and its meaning has already been demonstrated above. Small shape or material differences can mean large semantic differences (for example in the classification of objects such as amphorae, jewellery, buildings, altars, etc.).

In practical terms we need to decide how a semantic 3D markup system can be created most effectively. Currently this would require segmentation and markup which is mostly manual and in which subject experts need to be directly and extensively involved, though some semi-automatic support may be provided.

We need highly structured data that enable detailed examination. This is not about descriptive metadata, but semantic interlinking of content and detailed search (e.g., for parts of heritage objects, for instance, parts of buildings or statues). CIDOC-CRM-based semantic networks can play a core role in this.

For example, the Probado Project (PROBADO), which is funded by the Deutsche Forschungsgemeinschaft, has a vision of a 'Google for Architectural 3D Models'. Probado strives to integrate 3D into a real library (TIB Hannover) and bases its work on standards such as METS, Fedora, Ajax, Axis 2 and server-side GML. The background to this project is that each year hundreds of new architects are trained who could greatly benefit from this.

Interesting research questions in this work are, for example:

- What does 'content based retrieval' mean for architectural models, and for shape in general?
- How can search queries be 'formulated'?
- How do you create 'shape abstracts' (i.e., what semantic LODs are feasible)?
- Current classification methods may work for shape classes but are too coarse; for example to create an abstract of variants in styles. How do we achieve that?
- To what extent is it reasonable to assume that text-based markup will be the preferred, or even available, encoding of the knowledge of the content of digital 3D objects?

6.3 User-created content

The concept of user-created content as an integral part of our cultural heritage has a significant history of its own. In the European Framework Programs it received a significant boost under the '2001 Heritage for all' initiative, described in 2002 by Bernard Smith as follows:

> "Here the objective was to foster sustainable online communities in creating and documenting the digital record of their societies, including safeguarding its accessibility for the future. Projects were expected to be innovative and experiment in creating, manipulating or aggregating local resources and making them sustainable, visible and valid in the global context. One option was digital archiving applications integrating discovery technologies and tools, to provide easy access to the evolving digital record of the peoples of Europe at different levels of complexity and detail. Another option were tools and services that guarantee equality of opportunity and quality of discovery services and resources in support of social and cultural inclusiveness. The projects were expected to take account of ongoing national and regional heritage initiatives and digitization programmes. They were also expected to promote cooperation between different types of memory and cultural organizations at local/regional level, as well as appropriate public/private sector partnerships" (Smith 2002).

'Heritage for all' projects included CHIMER, CIPHER and COINE all addressing the personal views and interests of ordinary people in order to build a living picture of regional heritage across Europe. The MEMORIAL project focused on digitizing a wide variety of paper documents in libraries, museums and public records offices concerning the Holocaust and developed a methodology and tools for the creation of personal digital memories. (Still-accessible home pages of the mentioned projects are included in the *Bibliography*.)

User-created content takes several forms:

1. Recording of personal experiences for a variety of reasons. Citizens' personal experiences of a way of life, a place, an event, an organization, a social movement or other collective experience may be recorded. These recordings would often be of the experiences of the older generation in retrospect, but increasingly this involves

a cross-section of people and recording is at the time of an event. Thus there were many attempts to record the significance of the Millennium to different groups of people, countries etc. from the perspective of the full age range of those alive at the time.

2. Recording of other intangible heritage – for example, particular long-standing ceremonial occasions, traditional celebrations or orally transmitted cultural content (stories, songs, dances, etc.) which have both a personal component as well as a culturally-based and evolving set of cultural norms.

3. User-created content may also be commentary on items in a museum's collections where 'user' in this context may represent members of a community with specific knowledge. For example artefacts of social history are held in their millions in regional and local museums but the knowledge of specific artefacts' purposes may be incomplete in many cases. Access to the knowledge and memories of the community may well be a useful source of documentation of such artefacts.

4. In the UK there is an increasing public involvement in documenting archaeological finds away from the known and protected sites with the volume of finds recorded by the public and officially registered rising by 45% in 2005/6 to 57,566 from 39,933 in 2004/5 (DCMS 2007b).

These sorts of data are expected to form an increasingly important part of the curatorial responsibilities of memory institutions, as highlighted in Scenario 2 above. Methods and tools that allow for effectively capturing, extracting and presenting collective heritage and memory from user-created content are a particularly interesting field of research.

The implications for data recording are similar to those faced in collecting and analysing data for questionnaire-based surveys, combined with technologies aimed at creating a visual record of an event. At the surface level this involves recording oral interviews and visuals of events, but it is likely that the volume of such recordings would mean that without intelligent search and analysis tools the full richness of the data collected would be inaccessible. To make the data usable and useful a number of processing steps can be envisaged.

The oral data will require processing to produce transcripts and to associate metadata describing the context of the recording – what was being discussed, when it was being discussed (e.g., time separation from the memories), why was it being discussed (e.g., in the context of an anniversary, an event, an exhibition etc.), who was enabling the discussion, etc.

As with questionnaire data there would then be post-processing depending upon the features that were being examined. This could include isolating concepts being expressed in the discussion, with subsequent analysis looking for particular associations of concepts. Interview analysis is frequently undertaken in social sciences research, and the distinctive features for the developments expected in cultural heritage institutions will be:

- The volume of data becoming available;
- The concepts and questions being examined;
- The multi-cultural perspectives on particular events, ceremonies etc and the consequent likelihood of the set of transcripts being in multiple languages with additional difficulties of considering whether concepts from one culture have any equivalent in another;
- Relating multi-media recordings, where the oral recording may be undertaken whilst having a visual experience, for example.

As with the oral recordings, the visual recordings may require significant post-processing to make the resource useful.

There may well be aspects of recordings whose significance is not appreciated at the time of the original data capture. In the case of oral recordings, background noises, inflection, accent and emotion, these are all aspects that may not survive the transcription process and may become interesting in considering additional analysis later. For the visual recordings, background images are probably the most obvious additional information that may support additional analysis although not the primary subject being recorded. Other aspects such as the relationships between multiple recordings at a single event may also prove significant. This will also be shared with other current uses of multi-view data in reconstructing events in other disciplinary contexts:

- In crime and anti-terrorism, where multiple perspectives from news cameras or from security cameras around an area can be used to try to reconstruct events in 3D;
- In sport, where multi-view coverage of a sporting event (particularly football) is increasingly used to provide a 3D reconstruction for use by commentators.

Both of these are developments of technologies originally pioneered in environmentally-controlled motion capture studios and it is easy to envisage these technologies being used to capture the essence of a folk dance, for example.

Other analyses may imply radically different views of the primary visual data. In the same way as a revisiting of a body of primary oral data might allow analysis of development of regional accents, for example, visual data may provide opportunities for other research into societal change. An exhibit in the Millennium Dome recorded 250,000 individual, low resolution personal avatars of visitors. It is not difficult to envisage questions which might be asked of the social composition of visitors (apparent age distributions, for example) or perhaps examining other characteristics – clothing choices perhaps. As datasets are built up over time, analyses of the comparison and trends over the years might also become sustainable.

The degree to which datasets such as these can be used in alternative analyses will depend not only on the development of the technological tools, but also on the development of a societal willingness to permit alternative uses. This issue will be particularly focused where visual information from surveillance cameras observing 'normal' acceptable behaviour might be useful for other purposes, but nevertheless be seen as infringing the rights of individuals. However, there is a thin line between recordings where the analysis of background images might be (and have been) undertaken to provide evidence in cases of antisocial or criminal behaviour (for example at a football match) and using the background of recording of a specific event (e.g., a maypole dance) to provide additional research material on cultural behaviour. In both cases the existence of a warning that the event is being recorded and that attendees have given their permission for alternative uses of the recordings might be a legal necessity, but there will be debate outside of a research agenda on the moral and ethical dimensions.

In this Research Agenda we consider the technological advances that would be needed to sustain the data collection and analysis. We leave the ethical dimension to others to decide.

In section 8.4 the topic of user-created content is addressed from another perspective: The enormous growth in such content based on the use of 'social software' and content-sharing platform is described and the question posed of how cultural heritage institutions could overcome barriers to more openly involving online communities in exhibiting and interpreting cultural heritage. See also section 11.3 on the topics of diversity of cultural expression and heritage interpretation.

6.4 Intelligent tools

Many aspects of intelligent tools are appropriately discussed in other sections of this report. This brief section is included in order that the reader may realize that they are included despite no specific listing and discussion in a centralized piece of text. Intelligent tools in the context of the Research Agenda include all those areas where the tools and techniques to be developed are based on semantic knowledge of the cultural heritage domain. This includes primarily:

- The use of domain-specific knowledge to assist in digitization or reconstruction. For example the digitizations of a row of very similar, but damaged, statues might be combined to deduce the shape of a perfect original prototypical statue, which could then be morphed to match the remains of the individual instances and define 'perfect' versions of the complete set of unique statues (Figure 6.4).
- Semantic encoding and ontologies to support advanced search and cultural heritage research;
- The cultural and style specific knowledge embedded in proposed tools for procedural modelling; and,
- In the presentation area, tools which exploit the internal structure of the environments presented and the data associated with them to produce improvements in the experience. This improvement may relate to value added in the stories told or the underpinning real-time systems, which are enabled to operate more efficiently by exploiting the knowledge of the underlying semantics of the data.

It would be unsurprising for cultural heritage professionals to be sceptical about the building of intelligent tools into the processes they use. As the term 'professional' implies, they operate by exercising judgement based on knowledge and experience built up over time. This is a true use of intelligence in processing cultural heritage information and no professional group should give up this responsibility.

The sensitivity to intelligent assistance for the professional in their work will depend upon the implication of the assistance being insufficiently intelligent. Recent years have seen a great deal of thought given to appropriate levels of professional responsibility in subjects allied to medicine. How much professional knowledge and experience is needed to allow a nurse to make decisions about patient care, or to allow a paramedic in an ambulance to provide

care at the site of an accident before the patient can be transferred to a more specialized care environment? How do we strike a balance between the care given in a doctor's surgery and that administered only in hospitals? The 'implication of the assistance being insufficiently intelligent' in these cases is clearly life-threatening and the answers may well be different in emergencies. With cultural heritage professionals the implications may be less severe in terms of well-being, but may be as serious in terms of the subject of their domains.

Figure 6.5: Entrance to the temples at Karnak, and additional statues in storage from the original, much longer, avenues

The implication of the assistance being insufficiently intelligent is most damaging when there is no opportunity to reconsider and repeat a process. The most obvious cases in cultural heritage will concern:

- Archaeological or other data capture where the original circumstances are lost. Recording archaeological excavations is the most obvious case, but some other data capture may be difficult to repeat.
- Recording intangible heritage is an obvious case here, where it might be impossible to re-interview veterans of a particular conflict or re-create a particular event.
- Digitizing fragile material which is known to be deteriorating (e.g., ageing film or frescos open to the atmosphere) where the resource is known to have limited life and repeated digitization would potentially be both damaging and expensive.
- Recording threatened heritage environments (e.g., buildings about to be demolished) where there is a planned 'loss' due to a politically-determined balance of interest and an inevitable difference in opinions about the significance of the environment.

Of course, in this last case, where there is a time limit on the access to the original site it may well be that rapid techniques using techniques that have produced good results in similar situations are preferable to attempting a manual survey that cannot be completed accurately in time.

Of lesser concern should be those situations in which the experiment can be repeated. This is in principle true of all cases where the primary data is retained and is enabled by recording the provenance and paradata associated with the conclusions drawn by the (insufficiently) intelligent system. There are, however, other concerns that will naturally arise.

Systems which create believable results tend to be believed. The obvious cases of this come from the entertainment industry. Magicians rely on creating belief in the conclusion that a logically impossible set of apparent facts is nevertheless possible – the elephant really did 'vanish into thin air' rather than 'just' cease to be visible – no small feat in itself of course!

In the context of ICT in cultural heritage the most obvious concerns are where visual reconstructions are produced and become fact in the mind of the viewer. Even documenting uncertainty is not enough to relieve the concerns. Visual data is fundamentally different in terms of believability. There is no equivalent in visual paradigms of the footnote in text and a textual footnote might well not be read, or if read, accorded less impact on the messages taken away from the visual material. The message 'the events depicted in this film are entirely fictional' does not prevent the public from believing that there is an element of underlying truth in the film. The visual dimension represents a whole family of facts and the fictionality or otherwise of selected facts becomes buried in interpretation. Indeed the whole industry of product placement in films relies on this. The fact that a particular manufacturer makes cars we know to be true. In this science fictional account their cars are capable of amazing things and therefore we 'know' that their cars are amazing.

There have to be concerns, even where unfounded, that the same can be true in cultural heritage messages. To take an example, the placement of avatars representing a particular cultural background in a virtual reconstruction of a different cultural background might be taken as implying a link in history that did not exist, or is highly speculative, or did not occur at the dates being reconstructed. Whilst this may be relatively easy to spot with avatars it is rather less easy with artefacts. The placement of particular styles of architecture in inappropriate regions or at inappropriate dates of reconstruction may be painfully obvious to a cultural heritage professional and pass unnoticed (but subliminally absorbed) by the lay member of the public. Whether such situations are important is of course debatable, but researchers in these fields need to be extremely conscious of the concerns and a sensitivity to the issues might be a requirement of any project as 'inter-cultural ethics', in the same way as ethical considerations, are raised for research with medical or social consequences.

6.5 Semantic and multi-lingual processing

This section deals with the research background and needs for those seeking to enhance the following types of processing of Cultural Heritage data:

- Content analysis (e.g., extraction of base information and co-references from free text sources)
- Collection formation (classification and indexing)
- Cross-collection interrogation, (harmonisation and mapping between different collections' formulation, classifications schemes etc)
- Knowledge discovery (or "excavation in the digital domain")

6.5.1 Ontologies, taxonomies and thesauri

A great deal of research has been undertaken into various levels, structures and mechanisms for providing frameworks suitable for supporting searches and organization of complex bodies of information relating to specific domains of knowledge. The TEL-ME-MOR project recently published a report on subject access mechanisms which includes an analysis of some of the conceptual levels in use in National Libraries (TEL-ME-MOR 2006, 8-13). The report's conclusions show the variety of systems in use across the National Libraries for access to the materials documented in their conventional catalogues and shows how far there is to go to achieve integrated cross-collection search in consistent bases.

The three related concepts in this section's title seem to engender a great deal of misunderstanding, debate and redefinition by different groups, both within cultural heritage and elsewhere, for different purposes. Tom Gruber defines an ontology as follows:

> "The word „ontology" seems to generate a lot of controversy in discussions about AI [artificial intelligence]. It has a long history in philosophy, in which it refers to the subject of existence. It is also often confused with epistemology, which is about knowledge and knowing. In the context of knowledge sharing, I use the term ontology to mean a *specification of a conceptualization*. That is, an ontology is a description (…)

> of the concepts and relationships that can exist for an agent or a community of agents. This definition is consistent with the usage of ontology as set-of-concept-definitions, but more general. And it is certainly a different sense of the word than its use in philosophy. What is important is what an ontology is *for*. My colleagues and I have been designing ontologies for the purpose of enabling knowledge sharing and reuse. In that context, an ontology is a specification used for making ontological commitments." (Gruber 1992)

This definition of ontology appears to match closely the commonest usages in Cultural Heritage. The terms of ontology, taxonomy and thesaurus are used to refer to related but independent concepts in this report. According to the Wikipedia entry,

"A formal definition of a thesaurus designed for indexing is:

- a list of every important term (single-word or multi-word) in a given domain of knowledge; and
- a set of related terms for each term in the list.

Terms are the basic semantic units for conveying concepts. They are usually single-word nouns …"

The same entry describes how thesauri databases often include classification systems:

- "Thesaurus databases, created by international standards, are generally arranged hierarchically by themes and topics. Such a thesaurus places each term in context, allowing a user to distinguish between 'bureau' the office and 'bureau' the furniture. A thesaurus of this type is often used as the basis of an index for online material. The Art and Architecture Thesaurus, for example, is used to index the national databases of museums, Artefacts Canada, held by the Canadian Heritage Information Network (CHIN)." (Wikipedia 2007)

In addition thesauri include synonyms providing a structure that relates similar concepts in the thesaurus. For many purposes a hierarchical structuring depending upon meaning would be construed as a taxonomy, whereas the inclusion of synonyms would be providing information on the meaning of the words. However, as the above reference to the word "bureau" highlights, many words have meanings which are context dependent.

A taxonomy as used in this report is a classification according to an ordered system that indicates natural relationships, with a resulting catalogue which can be used to provide a conceptual framework for discussion, analysis, or information retrieval.

An ontology provides a set of concepts and relationships in a domain of discourse. Thus glazing material and window frame are at one level independent terms that might be included in a thesaurus on architecture. Each represents a class of instances or sub-classes (types of glass, Sealed Unit Double Glazing, plastic, etc. or frames with different designs and materials, etc.) which themselves may be included in the thesaurus.

The taxonomy draws together those thesaurus entries into the set of relationships. In this case there is probably going to be a taxonomy entry which includes the concept of a window having both frame and almost always glazing material each of which have a number of potential values and sub-classes. However this arrangement of information classes would not encapsulate the concept of a consistent architectural style, in which a particular design of window detected whilst scanning an architectural ruin would provide considerable supporting evidence for interpreting other evidence. This might have implications when deciding the likely doors, room proportions, façade decorations, overall building scale, etc.

An ontology describes the structure of the concepts, bringing together the concepts in the thesauri with the classifications in the taxonomy. It incorporates knowledge of the structure of the information in the domain of discourse. At present the information systems that operate in support of cultural heritage organizations are based on classification systems that include the explicit encoding of a hierarchical taxonomy. Our ability to provide computer-based assistance in reasoning about the significance of the individual artefacts and the relationships between them will depend on being able to organise knowledge from different perspectives and in different domains. In addition quantifications of these domains should allow the development of more intelligent tools to detect and encode particular features.

Cultural heritage presents other unique challenges in that languages and concepts vary between different cultures and over time. This means that the thesauri and related taxonomies and ontologies have more contexts to take into account and yet the very nature of inter-cultural understanding requires that we are capable of moving meaning from one to another.

The definition of such classification systems for language used in cultural heritage is not only the province of the dry and precise vocabularies of the professional. Indeed with the rising importance of user created content it will become increasingly important that the evolution of language is taken into consideration at an ever faster pace.

Thus thesauri of popular cultural terms would need to accommodate "spiffing", "hip", "cool" and "book" as words which imply a similar position in terms of the cultural situation which is described in this way, but also imply different generations using the terms. We note in passing that the use of "book" in this way is still not widespread but arises as a product of a very specific technology as it represents the word "cool" as a favoured alternative in some predictive text systems used for SMS messages. It is also worth noting that the last three words all have very distinct meanings in other contexts and that in this case we are only dealing with English (although some popular terms are used in more than one language). The language of the professional in these terms is better documented and more stable.

6.5.2 Folksonomies

Platforms for sharing user created content (e.g., Flickr for image sharing) or bookmarks (e.g., del.icio.us) and widely used "social software" tools such as Weblogs have brought about an explosion in user generated content categories, keywording and other annotations. In contrast to a formalised classification of resources that makes use of a controlled vocabulary, in these Web environments "folksonomies" emerge through an unconstrained process in which many people use their own freely chosen categories or keywords.

There has been much hype about folksonomies as a revolutionary, "non-binary" and "democratic" or "inclusive" way of organising Web resources. The following introductory paragraph to a useful overview of aspects of folksonomies illustrates the high expectations placed on them:

> "There is a revolution happening on the Internet that is alive and building momentum with each passing tag. With the advent of social software and Web 2.0, we usher in a new era of Internet order. One in which the user has the power to effect their own online experience, and contribute to others'. Today, users are adding metadata and using tags to organize their own digital collections, categorize the content of others and build bottom-up classification systems. The wisdom of crowds, the hive mind, and the collective intelligence are doing what heretofore only expert cataloguers, information architects and website authors have done. They are categorizing and organizing the Internet and determining the user experience, and its working. No longer do the experts have the monopoly on this domain; in this new age users have been empowered to determine their own cataloguing needs. Metadata is now in the realm of the Everyman." (Kroski 2005)

Inevitably, many contributions to the discussion about the value of folksonomies contrast them with formal classification systems such as taxonomies or ontologies and criticise the latter as "top-down", "exclusive", and "overrated". (Shirley 2005) A more appropriate comparison may be "trees" (taxonomies) versus "leaves" (keywords) and to admit, "This is not an either-or. The old way — trees — make sense in controlled environments where ambiguity is dangerous and where thoroughness counts. Trees make less sense in the uncontrolled, connected world that cherishes ambiguity." (Weinberger 2005) The analogy also suggests that the two approaches may be combined which actually has become an important topic of research. (cf. Quintarelli, Resmini and Rosati 2007; Mika 2005; Specia and Motta 2007)

There are many interesting aspects as well as shortcomings in folksonomies, but the following points may be of particular interest:

– *Reduction of cognitive effort:*

> "The classic ontology has a steep learning curve for construction and maintenance. Guidelines must be both well-planned and rigorously adhered to. Authoring a classic ontology is like having a typical Hollywood actress for a girlfriend - it is beautiful but high-maintenance." "To combat user aversion to external guidelines and preset taxonomy structure, folksonomies get rid of these guidelines altogether. This eliminates the learning curve, so that users are more motivated and more enabled to contribute metadata categorization and annotation." (Mote 2004)

Indeed, tagging resources with freely chosen keywords requires little cognitive effort and allows for some personal benefit, while the task of turning this "metadata" into a useful resource is off-loaded to the computing system of the platform that is used to share content, bookmarks or other information resources.

– *Exploitation of the user created tags:* The "leaves" that are raked together by the computing system for the most part are simple tags in a flat namespace, but can be exploited through mechanisms such as clustering keywords (e.g., "tag clouds") and presenting resources that have been tagged with the same keyword/s. This can allow for identifying some interesting resources, although there are "no semantics inside". Generally, users will not be interested in all resources that are available on a topic but the most popular or the latest additions.

– *Ethno-classification:* One of the most important strengths of a folksonomy is that it based on the vocabulary of the content users, which is particularly useful if they form a community of interest. A folksonomy that emerges in such a community may be a starting point for creating a professionally designed controlled vocabulary. Peter Merholz notes:

  "A smart landscape designer will let wanderers create paths through use, and then pave the emerging walkways, ensuring optimal utility. Ethnoclassification systems can similarly 'emerge.' Once you have a preliminary system in place, you can use the most common tags to develop a controlled vocabulary that truly speaks the users' language." (Merholz 2004)

At present there are only few examples of cultural heritage institutions involving individuals or communities of interest through offering the opportunity to tag and annotate resources. An excellently documented example of user-generated annotations of images of works of art is the steve.museum project. (Trant et al. 2007) In the field of archaeology, the Çatalhöyük project team has put excavation and other photographs online on the Flickr platform (http://flickr.com/photos/tags/catalhoyuk/). Some users have added a lot of tags and text to their photos, suggesting a high level of interest in, and engagement with, the material. (Ridge 2007)

6.5.3 Multi-lingual and multi-cultural knowledge bases

Figure 6.6: Multilingual Avatars Showcase – EPOCH
University of East Anglia, University of Braunschweig and University of Brighton

Even at the simplest level there are examples of issues which arise in multi-lingual operations. For example at a recent keynote presentation at VAST2006 Marc Küster highlighted the differences in operations as simple as organising a list of names in alphabetic order in different languages. Although this is only at a simple operational level the implications of this could be profound. For example this is of course more of an issue in searching through ordered digitized documents but might also become a factor in intelligent data capture of structure within documents. A further example would be the implications of particular character sets in the searching of full-text documents. A study by TEL-ME-MOR on the use of different character sets and the implications for classifying, sorting and searching sources has highlighted the potential difficulties.

"For instance, a search on 'Böll', 'Boll' and 'Boell' on current default collections shows that the British Library integrated catalogue ignores the Umlaut ('Böll' and 'Boll' give the same result set, 'Boell' does not), whereas SNL's Helveticat takes it into account ('Böll' and 'Boell' give the same result set, 'Boll' does not)." (TEL-ME-MOR 2005)

Languages have evolved in the localities in which they are used and reflect the needs of the local society to elaborate concepts relevant to them and the context in which they are used. The often repeated statement that the Inuit Indians have 26 words to describe snow and ice is clearly based on fact and on local need to distinguish between different forms. This may be of less concern in the Cultural Heritage field but the variations in popular culture terms in different societies all using variations of English would clearly not be insignificant. For most fields there are significant, though not necessarily extreme, variations, some of which can be handled by context or in extremis by special cases.

In archaeology however there are significant variations in the use of language at different times in different societies. These may also reflect needs for different levels of local distinction between similar concepts or indeed they may be a product of the gradual spread of particular cultural developments as people migrate. Hence a particular term might imply that an artefact was from a certain date in one region and from a different date elsewhere.

There have been some attempts at multi-lingual thesauri for cultural heritage. For example, the HEREIN multi-lingual thesaurus has a limited coverage of terms and the Canadian Heritage Information Network have added some 2600 French terms to the J. Paul Getty Arts and Architecture Thesaurus [Getty, AAT]. However these worthy efforts illustrate very clearly how much remains to be done in these fields if truly interoperable high level information systems are going to be developed.

An extensive and detailed survey led by the Minerva project (MINERVA 2006) has shown that there is indeed a lack of multi-lingual thesauri. This is due to several factors that make the creation of a domain thesaurus quite a difficult task when several languages are involved:

– There already exist implicit or explicit thesauri in the relevant languages, so the required task consists more in the creation of so-called inter-lingual thesaurus mapping than in the mere translation of terms into the various European languages. (see for example the EU IST project SWAD [SWAD, D8.3])
– There are concepts in some languages which have no, or multiple, correspondents in others. This is a typical problem of multi-lingual thesauri which is concentrated in those concerning culture, for the diversity of European history (see for example Doerr, 2001),
– Similar concepts have very different meaning in different places, even for very basic terms.

For example let us consider time periods. As the EU Culture2000 project ARENA demonstrated, there is no uniformity throughout Europe on archaeological periods, as shown by the diagram on the ARENA web site [ARENA] which illustrates the extent of the usual archaeological periodization in Palaeolithic, Neolithic, Iron Age, Classical, Medieval, Post-Medieval and Modern, represented by different colours in the picture.

For example, the year 600 AD is Middle Ages in Poland, is still Iron Age in Norway, is Early Medieval in UK, and (very late) Roman period for Romania. It would be Byzantine in Greece and other parts of the Mediterranean region, not covered by ARENA, but not everywhere.

As suggested by Michael Buckland (ECAI) in his lecture at the DEN 2006 Conference in Rotterdam (Buckland 2006), the most basic cultural concepts answer to the questions Who? Where? When? – but these rely on each other. People may take different names in different countries, geographic names may change their meaning through time, and time periods may differ, as seen above, from place to place. So multi-cultural thesauri must face the challenge of being time- and place-dependent while defining time and place concepts, a sort of internal recursivity which has never been properly dealt with by information science.

The effort from knowledgeable professionals to recognise and document the specialist terms in use in each language and culture would in itself be massive. The effort to extend this understanding so that the different implications of variations in systems evolving over time and place so as to align the information sources in different languages is clearly not available in the medium term. It is to be expected that advances will be incremental and projects should be required to think of the issues in general as well as the particular domain issues being addressed.

One of these general principles should be to try and understand the implications of including belief perspectives in systems attempting an interpretation of historic facts. Part of this complex set of interactions arises from the uncertainty of the "facts" themselves and part from the different cultural perspectives on the significance of those "facts" even where they are agreed. It is clearly true that the significance of an event is altered by the context in which it occurs – the most obvious examples being those where an identical criminal action may result if very different legal repercussions and hence the significance of the action must be viewed in context.

The French parliamentary debates in 2006 on "making it a crime to deny that Armenians suffered "genocide" at the hands of the Turks in 1915" (BBC News, 2006) and the fact that perspectives on the debate have been reported and commented upon differently in different contexts is an illustration of the contemporary needs to be sensitive to different cultural perspectives in interpreting information. Clearly the varying perspectives promoted by fundamentalists and extremists in any belief system are another manifestation of the difficulties here. The degree to which civilised societies place limits on the actions taken as a result of deeply held views will also influence the potential fields of research. To present the reasons a fundamentalist interprets a set of circumstances in a particular light may be part of a cultural landscape which it helps to understand. To attribute a rational logic from whatever

perspective to terrorism raised against innocent civilians is almost certainly an unacceptable interpretation of facts for the vast majority of society. Systems which seek to make logical deductions or interpretations based on an understanding of cultural perspectives would need to be aware of limits on the acceptable range of interpretations, at least from the point of view of presentation.

In the context of this Research Agenda such issues will not be addressed in any systematic way for the foreseeable future. What might be more tractable is to envisage systems in which potential belief is recorded as a perspective on facts or where the facts themselves are recorded within a range of uncertainty. Similar issues will arise in dealing with contradictory sources – for example secondary documentation or multiple perspectives on an event as primary sources from different witnesses.

In terms of future research priorities this analysis would suggest that the EPOCH Research Agenda needs to recognise that:

1. The fundamental problems underlying the semantics of cultural heritage are extremely complex and would require a great deal of basic research to address, if indeed they are addressable even in the longest timescales.
2. In the shorter term issues should be examined of documenting the characteristics of different cultures' design styles in different forms and using this documentation to assist in examining the consequences of style based capture analysis and modelling tools. This underpins different cultural bases both for the terminology and for the reconstruction tools considered in the section on modelling and reconstruction. There are considerable paper based resources which have recorded the underlying elements of design styles, with some addressing them from mathematical perspectives or based on particular shape grammars (see the description of intelligent digitization tools above and of generative modelling systems below).
3. The multi-lingual work to address challenges in terms of defining thesauri and inter-operability for documenting the cultural heritage of Europe is overdue and an essential underpinning to the semantic processing of CH data.
4. Creating and managing semantically recursive multi-lingual and/or inter-lingual thesauri as those described above is a task requiring new theoretical investigation and is probably a challenging one, definitely not trivial from an information theory perspective.

The next section considers the needs in terms of the typical processes in supporting the collection, long term availability and analysis of digital memories underpinning cultural heritage and the requirements in terms of creating such repositories.

6.5.4 Digital memories for cultural information integration

This section draws extensively on the presentation by Martin Doerr (Center for Cultural Informatics, ICS-FORTH, Greece) at the EPOCH Research Agenda workshop in Nicosia. (Doerr 2006)

Doerr defined his concept of Digital Memories (as opposed to Digital Libraries) as "Information systems preserving and providing access to source material, scientific and scholarly information, such as libraries of publications, experimental data collections, scholarly and scientific encyclopedic or thematic databases or knowledge bases." In fact this is quite close the definition of a Digital Library as conceived in the European Digital Library project in i2010. It is also in line with the new roles for local museums envisaged in Scenario 2 and in the future directions for museums in the UK. (DCMS 2006b)

However, the implications, in terms of research which is required, relate not just to the range of sources, the search connectivity (i.e., integrated multiple sources), or availability from any location. All of these require some research and a great deal of development, but the truly long term research requirements lie in the need to structure the information sources in ways which enable novel semantically-based search functionalities. From this perspective there are a number of problems relating to current generation digital libraries.

There is still a widely held and traditional view of the task of libraries as institutions limited to the collection and preservation of documents and to providing assistance in finding specific items of literature or information. According to Doerr, this view of the library's role is completed "when the (one, best) document is handed out. 'All you want is in this document.'"

This view has not helped much in raising the level of new functionality that semantic interoperability of resources would permit. In fact there are a host of problems in current generation digital libraries. In particular there is little or no support for the searches to produce new and informed responses from aggregated sources or to retrieve them by contexts (e.g., "Which excavation drawings show the finding of this object?"). There is little or no support to allow integration of complementary information in multiple sources into new insight (e.g.,, "What is known about

the people who participated in this excavation"). Finally there is typically no support for cross-disciplinary search (e.g., to find relevant related information from the many disciplines that contribute to archaeological knowledge, such as ecology, ethnology, biodiversity, etc.). Such searches would be content based and span multiple areas of the typical library classification systems as well as requiring semantic analysis of complete sources (both text and other data types)

Doerr identified as a "Grand Challenge" (see UKCRC for a description of Grand Challenges and Arnold, et al. 2006 for an example) the proposal that "Digital Memories should become integral parts of work environments as sources to find integrated knowledge and produce new knowledge, to create and defend hypotheses." Suitable knowledge management, which makes use of global networks of knowledge, would appear to be the key, distinguishing:

- Core ontological relationships for "schema semantics", such as: "part-of", "located at", "used for", "made from" which are localized atomic relationships, but rich in potential structural information, relating to content.
- "Categorical data": taxonomies used for reference to and agreement on sets of things, rather than as means of reasoning, such as: "basket ball shoe", "whiskey tumbler", "Burmese cat", "terramycine". These terms define and order concepts rather than providing structural information. They aggregate categories as opposed to integrating sources. The leaves of the taxonomic structure would be entries in a thesaurus.
- Factual background knowledge for reference and agreement as objects of discourse, such as particular persons, places, material and immaterial objects, events, periods, names. These would be elements of the taxonomic classes.

Doerr identified several preconceptions that hinder the evolution of digital libraries into digital memories with the required knowledge management support (Table 6.1).

Preconceptions	**Problems & solutions**
"Libraries should not depend on domain specific needs. Domains are too many and too diverse. DLs need a generic approach."	This "seduces us" to only employ intuitive top-down approaches for generic metadata schemata. As a result, when the fantasy is exhausted, research stops. Deep knowledge engineering is required to generalize in a bottom-up manner from real, specific cases to find the true generic structures across multiple domains. Interdisciplinary work is needed on real research scenarios to identify the relevant semantics. This will involve studying professional information scientists and evaluating the support needs of the ways in which they actually work.
Preconception: "Ontologies are huge, messy, idiosyncratic and domain dependent. Mapping is the only generic thing we can do"	This statement is mainly true with "ontologies" used as "categorical data" (term lists), with which the sector seems to be transfixed. The different character of ontologies describing "schema semantics" tend to be overlooked. These may well pertain to generic classes of discourse and interdisciplinary work is needed to evaluate this potential.
Preconception: "Queries are mainly about classes. The main challenge of information integration is the integration of classes (terms)."	This preconception is not in fact sufficiently supported by empirical studies. It seems more likely that query parameters pertain to universals and particulars and relationships in real research studies. Original research questions need to be systematically analyzed to understand the way repositories are evaluated in real research situations.

Preconception: "Manual work is not scalable or affordable. Only fully automated methods have a chance"	This preconception allows us to overlook the quality of manual, intellectual decisions in favour of an "affordable automation". Yet billions of people produce content manually. Wikipedia demonstrates that the preconception is not true and that in some circumstances useful and interesting results can be generated by enabling large scale mobilization of affordable manual input. Designing interactive processes to involve users in massive Virtual Communities / Organizations in the operations of cataloguing, "data cleaning" and ontology, taxonomy and thesaurus development would allow huge quantities of data to be captured in appropriate formats. We need semiautomatic, highly distributed algorithms and genuinely interdisciplinary work to achieve this in compatible and consistent formats.

Table 6.1: Preconceptions hindering development of Digital Memories (After Doerr, 2006)

There is a growing awareness of the need for information systems which provide reasoning capability, but before any "reasoning" can be done over integrated knowledge resources, the data must be connected in a "global network of knowledge." This requires:

– A sufficiently generic global model (core ontology with the relevant relationships).
– Methods of knowledge extraction / data transformation to populate the network.
– Massive, distributed, semiautomatic detection of co-reference relations (data cleaning) across contexts.
– Referential integrity of co-referencing needs to be curated in order to create, maintain and improve the consistency of global networks of knowledge as a continuous process (not making yet another independent database, but improving the quality of data through development of controlled new versions, whilst maintaining curation and provenance).

Only when a sufficiently rich information repository is available can we do advanced reasoning and intelligent query processing.

Research in cultural information repository generation should focus on "large-scale" information integration. It is feasible to create effective, sustainable, large-scale networks of knowledge, but the infrastructure needs have to be established to enable this.

For this Martin Doerr suggests four research directions:

1. Interdisciplinary research on research processes, questions and discourse to analyse:
   – Relevant query and general reasoning mechanisms;
– Relevance of the ontological constructs we use;
– Necessary granularity of ontologies.

2. Research on widely applicable global models.
– Empirical evidence for global models pertaining to a generic discourse and validating generic principles in other domains;
– Formalization of intuitive concepts and understanding of their relationships;
The CIDOC-CRM is an example of such a model that requires study, development and application.

3. Mapping and data transformation technology to extract and summarize information into a form suitable for integration:
– Extraction tools to analyse sources and extract structured information;
– Architectures/techniques to integrate knowledge preserving links to the sources;
– Mapping tools, data transformation generators.

4. Identity negotiation and preservation of co-reference relations:

Research in these areas is necessary to quantify the way in which ranges of interpretation contexts can be represented and analysed. This research touches on issues of national, ethnic and belief perspectives and needs to:

– Research states of knowing and agreement on identity;
– Manage global processes of improving size and quality of co-reference clusters (generalize over authority files);
– Build social organization forums (communities) preserving the integration of knowledge.

In theory all four are needed together but in practice, without the first, research on other topics would continue to be "blind" to what the real issues are. We endorse these recommendations.

6.6 Visualization and presentation

The subject of this section is "visualization and presentation" which might be taken, by technologists, to refer in a strict sense only to image generation. However the word "visualization" is used in many contexts to describe the activity of reconstructing or recreating environments. Tools in this area are not capturing the shape and appearance of what exists – they are recreating an impression (hopefully an accurate impression) of the past from the present evidence.

There are two fundamentally different paradigms to present computer generated imagery, namely films and interactive 3D. The first implies that images are rendered offline. In some ways this is less of a problem since almost all modelling tools incorporate a (nearly) photorealistic renderer, but the ease of authoring a script and assembling the assets has some way to go in order to allow effective production of filmed sequences by Cultural Heritage professionals. Hence in practice there are two other issues that are more difficult to accomplish:
– the creation of individual models that are to be incorporated in displays, and
– the assembly of compelling virtual worlds for interactive rendering.

© Multilingual Personalised Information Objects (M-PIRO) project

Figure 6.7: M-PIRO image, for further information on the M-PIRO project see Ross et al., 2005, pp. 92-96.

The latter, in turn, has also implications for modelling, and this is why both related subjects are in focus in this report. The situation for visualization and interactive rendering is characterised today by a fundamental dichotomy, the separation of the model creation from the interactive virtual inspection. The process is always basically as follows:
– Individual model creation – either by shape acquisition or by manual modelling for synthetic shapes
– Export and preprocessing – to make sure the created world is amenable to interactive inspection
– Assembly and authorship of the complete 3D environment.
– Interactive Viewing – ranging from simple 3D model inspection to rich responsive virtual worlds.

6.6.1 Procedural Modelling

3D modelling is still mostly an expensive affair and predominantly undertaken manually. As a result, such efforts have been focused mainly on major monuments and sites. Little attention has been given to the modelling of modest dwellings which constitute the majority of buildings such as houses, barns, small workshops, etc. Bringing

the past to life again is a major goal often cited when producing 3D models. It goes without saying that such an endeavour is bound to fail if only the most spectacular aspects are visualised and the everyday part of people's living environments is omitted.

New developments in procedural modelling hold great promise for cultural heritage for modelling the vast numbers of relatively routine buildings which would be part of any historic, urban environment. Based on grammatical and parametrical descriptions of shapes (for instance of the architectural style of buildings for a targeted period) models consistent with these descriptions can be produced quickly and at low cost. As a result, large-scale modelling projects can be undertaken, as already exemplified through EPOCH's 3D model for the entire Pompeii site. (Mueller et al. 2006)

Moreover, the ability to produce massive models efficiently opens up the opportunity to do so multiple times with parametrically controlled ranges of variation. This offers new ways of expressing degrees of uncertainty about the virtual reconstructions. The need to represent and convey uncertainty is fundamental for cultural heritage where images giving impressions of the past may contain large parts which are based on informed conjecture (i.e., made up, based on varying degrees of evidence).

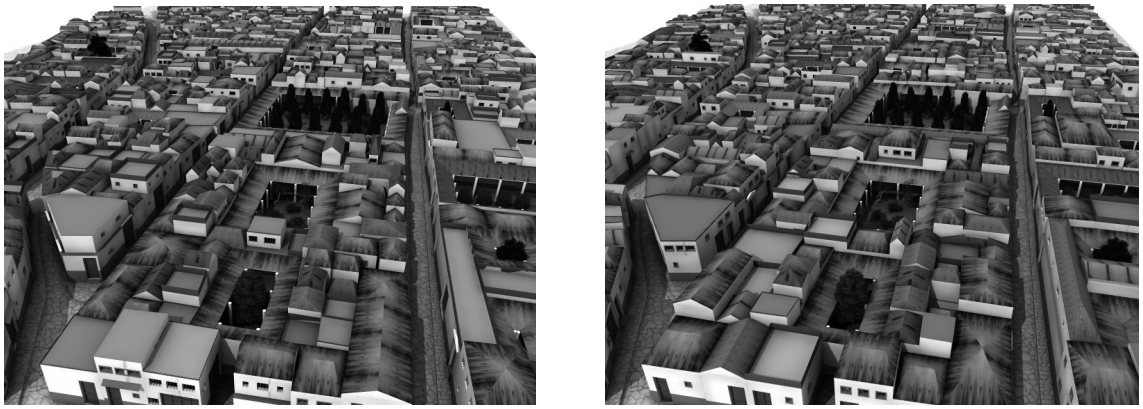


Figure 6.8: Two alternative procedurally generated models of Pompeii (Mueller et al. 2006)

Traditional approaches to expressing uncertainty have been based on showing that uncertainty within the display of a single model. However, when the opportunity is available to build reconstructions cheaply and easily, more than one can be produced (Figure 6.6) and the collection acts as `the model', rather than any of the individual reconstructions. The collection samples the space of possibilities, where elements with great certainty tend to reappear often in the form, whereas elements that are very uncertain will vary greatly from one reconstruction to the next.

This novel paradigm for expressing uncertainty would have been unsupportable without the developments in modelling techniques and should be evaluated for effectiveness alongside other, more conventional, approaches such as non-photorealistic rendering of areas of conjecture.

Technological research challenges in procedural modelling

The current ETHZ work for EPOCH on procedural modelling of urban environments (Mueller et al. 2006) has been recognised as some of the most advanced of its kind as evidenced by its inclusion in the ACM SIGGRAPH paper and tutorial sessions. Here is an overview of some of the research challenges, from an EPOCH specific point of view, as well as beyond.

1. *Combining procedural modelling with multi-resolution and generative detailing:* In EPOCH's terms this research area would combine the shape grammar functionality of procedural modelling to integrate parametric shape descriptions (such as those offered by the Generative Modelling Language (GML) in order to create shapes with adaptive, dynamic level of detail to be included at the level of leaf nodes in shape grammars) (Berndt et al. 2005)
2. *Efficient level-of-detail (LoD) descriptions should involve some level of semantic understanding:* Good results are difficult to achieve when only operating at the level of triangles and their textures. The shape grammar approach provides a natural, hierarchical description of buildings, and it should be investigated in how far this

hierarchy can be automatically translated into better LoD representations. This is of paramount importance if one wants to efficiently render the large scenes that procedural modelling can help to generate.

3. High-detailed 3D modelling for non-expert users: Entry-level 3D modelling tools can have great impact, as for instance [SketchUp] which permits all users to easily create a rough sketch of their houses, and to insert them into GoogleEarth. However, creating highly detailed architectural models with such tools is too laborious. The CHARISMATIC modelling suite (Day et al. 2004) demonstrated the use of modelling operations based on constraint-based drawing-type interactions and provision of detailed style-based libraries for architectural details. The combination of easy sketching operations and interpretation, constraint-based modelling and style-based libraries of procedural detailing would provide a greatly improved tool for researchers and scholars to formulate their hypotheses in 3D in unprecedented precision. Improving the availability of such modelling for inspection by peers (including the decision making and selection of alternative interpretations) would also lead to more rigorous reconstructions.

Figure 6.9: (a) The Site of the former Ename Abbey today
(b) The virtual model of the abbey complex at Ename (Belgium) superimposed on the current setting

4. Integration of additional layers/GIS: Current modellers (including procedurally-based and more conventional systems) already have some provision to cater for streets and vegetation. However there is insufficient integration of general purpose modellers and domain specific needs in these areas. These facilities need to be improved and additional layers should be included. Moreover, the reconstructed models need to be coupled directly to GIS systems, but the mechanism and formats for this will depend on ongoing discussions about appropriate geographical standards for cultural heritage (KML vs. GML, for instance).

Figure 6.10: (c) Aerial View of the virtual model of the abbey complex at Ename (Belgium) superimposed on the current setting. For more information see (Vergauwen 2004)

5. *Standing structures as constraints:* Often, buildings are still intact or still have some substantial standing structures that remain. In that case, a modelling tool for architectural heritage should take images or scans of the standing structures as input, and use this information as constraints on the allowable reconstructions, potentially combining this with knowledge of the rules associated with the style represented by the remaining evidence of the standing structures. The task would be to build a 3D model from images or scans, but with the important, additional help of a grammar describing the architectural style of the building and the important additional task of extending the fragments of standing structure to achieve a complete building meeting both the constraints of the standing structure and other information about the full extent of the original structure. In case the standing structures are incomplete, part of the task will in most cases consist of filling in missing structures, based on the grammar and possibly additional iconography.

6. *Coverage of styles:* In the same way as OCR techniques have developed to allow for increasing ranges of font styles (both current and historic) the vocabulary of design styles and composition rules needs populating and the range of compositional rules needs refining. This is a substantial piece of work, which may become informed by the research proposed under 7 and 8. However in the interim and in order to feed the research proposed there with base analysis and case study data, there will be a need to investigate a range of styles through more traditional analytic research. Some substantial work has already been under taken in these areas by the design community for some styles (most notably classical Greek and Roman architecture), but this needs to be elaborated and re-thought in terms of the parameterised algorithmic nature required by shape grammars and the reverse processes of style recognition.

7. *Learning grammars:* With procedurally-based modelling, based on rules which implement particular styles and classes of object, a lot of the detailed modelling work is built into the modeller and taken off the shoulders of the person (investigator) producing the final model. On the other hand, the underlying grammars and parametrical descriptions have to be generated. This is something the investigator might have to do, if a similar style has not been previously captured by someone else. If such style grammars could be created automatically, or semi-automatically, drawn from analysis of images of representative instances of a style this would further reduce the effort for future investigators and make the generation of reconstructions more efficient.

8. *Determination of style:* Once the grammars for a sufficient number of styles have been developed, and grammatical descriptions can be fitted against images as under item 4, one could compare the success different styles have in explaining the visual data about an object like a building, and automatically determine its style or mixture of styles.

This section has concentrated on the specific research needs identified in procedural modelling as a technique for visualization of architectural reconstructions and for compact representation of very large models of urban environments. The property of compact representation of highly detailed models is shared with other applications of procedural modelling including the sub-division surface techniques for architectural detail and the procedural modelling of materials. Procedural modelling appears to be the best practical alternative at present for detailed modelling of extensive environments. Architecture was taken as a good case in point, but procedural modelling should be seen as a paradigm with generic potential for any type of objects that are structured according to some kind of `rules', be it natural as certain fossil types in palaeontology or man-made like art nouveau vases in art history.

In the next section we will discuss briefly some other more general research needs particularly in the presentation area.

6.6.2 More general research topics in visualization and presentation

Having addressed the issues of representing reconstructions of large-scale historic environments efficiently the major outstanding issues relate to the needs to present these environments and their associated information to the target recipients. These presentation situations have different characteristics depending upon the purpose of the presentation, the major forms of which will be presentations to cultural heritage professionals for assistance in analysis and research and communication with a wider audience with educational and/or recreational objectives. Three major sub-areas are envisaged:

(a)The linkage of models capturing the appearance of environments to the underpinning structured knowledge base about the history and significance of the environment's constituent components. This is an issue at both scene assembly and during the presentation of the environments:

– Tools and techniques to allow presentation of provenance, paradata (cf. London Charter), interpretation and uncertainty;
– Asset management and version control: What is the significance of editorial actions in terms of derivative works? How does the investigator record, visualize and understand the provenance of the range of assets being assembled? What are the fundamental operators for combining uncertainty and provenance of individual components to produce the provenance and uncertainty measures of the total assembly?
– Revealing the underpinning information: What are the appropriate paradigms for communicating the non-visual information associated with the components of the scene? Given the full richness of future knowledge bases this needs to include appropriate filtering and packaging of the available information as well as navigation tools to allow the professional or interested amateur to explore beneath the surface. At the same time it must be possible for curators and other professional exhibition designers to create purposeful yet interesting and engaging presentations with sufficient accurate information;
– Representing uncertainty acceptably is still an important research topic with both the traditional means of varying the presentation mechanisms and the development of alternative content approaches to be investigated further for efficacy and impact.

(b) Authorship tools to allow non-ICT specialists (and in particular cultural heritage professionals) to experiment, design and author using extensive digital assets in appropriate ways:

– Authoring tools tailored to cultural heritage presentations, linked to digital cultural heritage assets embedded in a digital context;
– Authorship tools for cross-platform and multi-platform interactive systems (e.g., delivery via iTV, computer games machines and other domestic-level technologies, Internet and location-based immersive VR/AR systems in memory institution visitor venues);
– Frameworks for authorship of multi-cultural, multi-national, and multi-lingual presentations and multifaceted interpretations. These frameworks will need to be based on mechanisms that allow the varying perspectives to be captured and represented;
– In the longer term, understanding the characteristics of an interactive experience that produce a sense engagement for the user and developing measures of engagement to inform authorship tools and assist authors in producing engaging experiences.

(c)Novel interface techniques for exploring the resulting environments. In general these areas relate to adopting and appropriately adapting generic techniques and technologies. These will become specific to the cultural

heritage field, where there are specific requirements. For example, there will be specific issues in adapting generic haptic technologies and allowing these to address the needs of interfacing to measure of uncertainty (perhaps represented by deformable objects) or provenance.

– Development and deployment systems for Augmented Reality interpretations used with replica and/or original artefacts. This area involves the augmentation of the presentation of physical artefacts using virtual presentations involving digital assets. The technique has been used in a number of very promising early adopter schemes as a way of adding to the experience of the physical object in ways which preserve the security and integrity of the original pieces. In particular the ability to investigate the detailed internal structure and magnify the intricate aspects in a virtual surrogate allows the visitor to appreciate the detail of the original artefact at a level which could not be achieved with the original. This also helps to address issues of access for the visually impaired.

Figure 6.11: Augmented reality reconstruction of the Sagalassos Site

– Experimentation with ambient technologies in museum and visitor centre contexts: This topic covers the use of location-based sensors, visitor identification systems and controlled, focused environments for sound. These technologies are under widespread research and development for many applications ranging from customer service environments, office operations and security systems. The museum and visitor centre sector provides a range of challenges which are different from those of other contexts. For example, the need to offer multi-lingual capability with visitors of unknown origin might be shared with customer service environments in airports, but is more prominent here than in the controlled office environment. The major issues are likely to be those of integration into other museum and visitor centre systems – linking to the digital repositories and presentation systems, for example. The issues to be addressed are nevertheless significant, particularly for wide-area, open-air sites and those with the densest throughput of visitors.
– Effective personalization of experiences for repeat visits or linked venues: This area concerns the identification, profiling and linkage of activities of individual visitors. There are issues of privacy, which it is assumed will be overcome by making the enhanced services sufficiently attractive as to ensure that visitors will wish to use the services. Mechanisms for identification are a generic issue being widely trialled in commercial and security operations with technologies being continually improved for identifying individuals. More challenging is to

understand effective ways of using the identification of the individual to profile their interests, tailor experiences and provide value-added services. Given the potential to offer multi-cultural perspectives on the information presented, the capability to tailor experiences must also take the research into the realms of ethical issues. For example, should a tailoring system automatically challenge or reinforce particular individuals' perspectives by choosing confrontational or reassuringly familiar perspectives from which to present the stories of the past? The first might be considered more educational; the second might make better commercial sense.

– Appropriate use of haptic technologies: Of the five senses, most effort has been placed on sight and sound as the vehicles for presentations and interactive systems. Touch is probably the next most promising (i.e., more likely to be effective than smell or taste in human–computer communications). 'Haptics' cover both technologies to provide tactile stimulation (i.e., sensations at the skin) and force feedback (i.e., exerting force on the musculo-skeletal system). Technologies targeted at exploiting this potential have existed for many years, but have made little penetration into cultural heritage applications. Where they have been deployed in the theme park sector, they have not been universally successful in operations despite a more favourable investment regime. There are a number of good reasons for this. In particular, robust technologies have been very expensive and the cheaper devices lack the richness of interactive capabilities; this is quite apart from concerns about sustainable operations. Operational concerns include health and safety aspects (particularly hygiene) and the robustness of devices under repeated use. Nevertheless it can be anticipated that haptic devices may have a place in the range of interactive techniques used in cultural heritage, particularly as cost:performance improves and devices become more robust.

Aspects of haptics that need more investigation include:

- What aspects of touch can be usefully exploited in cultural heritage contexts?
- If surface texture is an important communication opportunity, how should it be represented in the environment?
- What are the architectural implications for applications using haptics, which require a much faster refresh rate than images, with the very large environments envisaged?
- What cultural heritage research investigations would be enabled by having haptics embedded, and what would be the consequent needs elsewhere in cultural heritage research?
- What additional presentation opportunities might be augmented by using haptics? Examples could include replaying the process of restoring an object, or the sensations of making an artefact (e.g., cutting gemstones to create jewellery, or knapping flints to make tools).
- For example, haptics have been proposed as assistance to an archaeologist in reconstructing large architectural features. The idea is that digital models of the heavy extant fragments of structures can be reassembled virtually using haptics to provide tactile feedback of the fit of the pieces. To enable such an application would of course require the accurate digitization of all the potential fragments. Given that these may weigh several tons and, in situ where they lie, would normally be partially buried, even where they are accessible. The application therefore is predicated on the assumption that acquiring digitization of the stone fragments is practical – by no means a foregone conclusion.
- The INTUITION NoE on Virtual Reality has a working group developing a research agenda and road map for haptic technologies (INTUITION 2006).

– Speech-enabled, multi-lingual systems accessing domain-specific knowledge for story-telling and/or research: 'Speech-enabling' involves a number of generic technologies. For conversational systems, speech recognition, speech analysis (commonly involving partial statements as opposed to the complete sentence structures assumed in most written text analysis), context awareness, negotiation of common understanding, response generation and voice production are all parts of a speech interaction cycle. All of these would be involved in any generic conversational system, although the breadth of untrained voices to be interpreted makes any visitor-orientated application including cultural heritage particularly challenging. Areas where cultural heritage presents significant additional challenges include the specialist thesauri involved as well as the range of languages (including historic languages).

– Avatars in interactive public environments: Avatars, including virtual humans, are one presentational mechanism for interfaces, including conversational interfaces. The generic issues which arise here are mainly to do with the acceptability of particular types of virtual communicator. There has been an ongoing search for techniques to define and present the most life-like of virtual humans, but there is still a degree of scepticism that a faithful reproduction of a human is attainable or desirable. The attainability concerns reflect the sensitivity of human

recognition systems to slight imperfections, which may concern both the appearance, including the motion and deformation of soft tissue, and to the virtual human's reactions, which relates to a mixture of appropriate expression, responsiveness and apparent intelligence. An alternative to a faithfully reproduced virtual human may be a characterization which makes no pretence at fidelity but provides an engaging communication style.

Figure 6.12: Maïm, Jonathan; Haegler, Simon; Yersin, Barbara; Müller, Pascal; Thalmann, Daniel; Van Gool, Luc (2007) Populating Ancient Pompeii with Crowds of Virtual Romans. Proceedings of the 8th International Symposium on Virtual Reality, Archeology and Cultural Heritage - VAST, 2007© EPOCH, 2006

Finally in the interfaces area it is important that interfaces and the technologies/techniques that support them are developed to allow cultural heritage professionals to work in their domain of expertise rather than become ICT specialists in order to use tools developed from the technologists' perspective. To do this, analysis is required of the ways in which real cultural heritage professionals undertake specific tasks and the interfaces to applications need to be built for the convenience of the CH professional in undertaking their normal working tasks. For example, it would be desirable to produce interfaces that a CH professional can use to create and manipulate structures in a specific style/shape grammar, expressing operations in terms of the normal vocabulary of operations used in that domain. This sort of approach is essential to capture the skills of the professional in (in this case) evaluating alternative interpretations of the extant physical remains efficiently.

6.6.3 Additional ICT support in environmental assessment, restoration and reconstruction

In addition to modelling for visualization there are also several potential applications for digital restoration techniques (e.g., simulations of stone deterioration).

Conservation specialists have in-depth knowledge of erosion and weathering processes of stone, and how stone breaks when subject to strong forces (such as earthquakes). If we could model such processes in 3D and time, we could envisage using this knowledge to reverse the processes in digitized statues, monuments and archaeological remains. Having this kind of intelligent tool, combined with the style-based, domain-specific understanding of the range of likely shapes involved, means that it may become possible (probably semi-automatically) to reconstruct digitized weathered or damaged objects into the representations of the original and undamaged objects. (See for example the image below (Figure 6.11), where the damaged archaeological remains in Sagalassos are digitally put together through software that matches break surfaces. Turning this assembly into an unbroken and undamaged frieze remains a fully manual process, currently even without specific objectives to understand and reverse the weathering processes.)

This kind of computer-aided digital restoration would be very useful to show the splendour of the original object without altering the physical original (which would be, in most cases, a quite irreversible and inappropriate process). Similar reverse ageing processes could be envisaged applied to timber-framed building construction, which distorts over time as the beams sag. The extent to which this is possible will of course depend upon the degree of damage and the availability of material samples to allow an understanding of the underlying science.

In the photographs of the object in Figure 6.12, we see several forms of local erosion (due to the acid nature of the soil), damage (the ivory is broken in several places and parts are greenish due to corrosion of the bronze pins)

and deformation (the parts do not fit together any more) that could be corrected if good models and tools were available to 'undo' these shortcomings on the digital model.

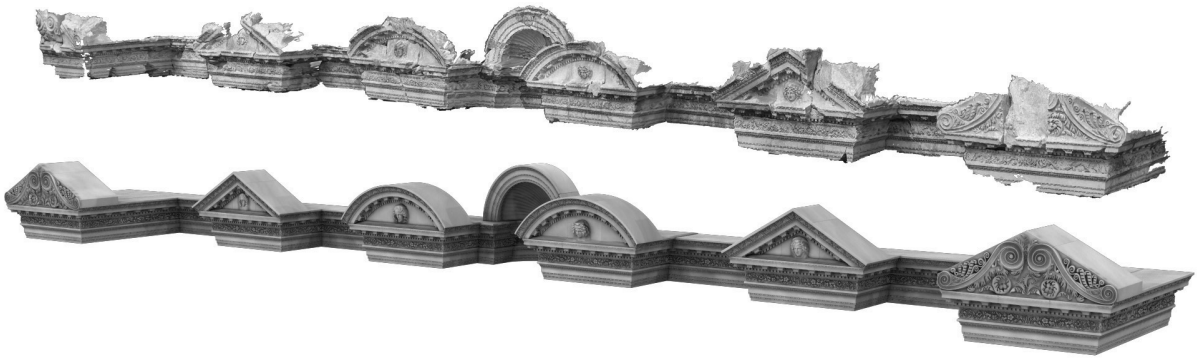


Figure 6.13: Original and digitally restored frieze of Nymphaeum – Sagalassos

By experimenting with digital restoration, the restorer can learn a lot about the structure and creation of the object. By showing the restoration as a time-lapse animation, one can show the nature of the damage and create insight for the visitor into the work of the restorer.

This modelling of weathering, damage, colour bleaching, salt crystallization, wear and erosion processes is a very multi-disciplinary approach, capturing the knowledge of conservation specialists. It is especially relevant in popular visitor centres where the visitors themselves are a major source of damage to the environments they visit. Figure 6.13 shows the hall tiling in a chateau in the Loire Valley where generations of visitors have not only worn the surface of the tiles and removed all trace of imagery over most of the floor, but the underlying tiles themselves are worn to a depth of perhaps 1cm in areas of major footfall.

Some research is going on in this field (MIT, Microsoft Asia) but it is still in its infancy. The new Science and Heritage Programme of the UK Research Councils also has work in this area as part of its expected scope.

Figure 6.14: 11th century ivory object with different types of erosion, damage and deformation

Figure 6.15: Worn tiles at main visitor entrance of a much-visited Loire chateau

6.6.4 Specific issues for Web access and dissemination

This section draws on the contribution by David Bearman to the EPOCH Research Agenda workshop at VAST2006 in Nicosia. Bearman's contribution addressed various museum issues and open research questions in an emerging 'Research Agenda for Museums on the Web'. In this section the aspects most related to the specific needs of operating over the Web are emphasized, although the contribution also re-emphasized other aspects of the Research Agenda.

One aspect of the potential for museums on the Web is that it is important to articulate open CH ICT research questions in such a way that museum directors and staff can see how the museums' work could benefit from ongoing research in the field. It is important to recognize that (as Bearman stated) "Museums aren't well endowed or technically sophisticated so solutions need to be easily implemented", and "Evaluation, in actual contexts of use, is critical."

The role of Web technologies in the 'Museums on the Web' context is to re-emphasize some attributes of application situations. In particular the limitations of communication speeds highlight the need to consider what constitutes sufficient accuracy. Museums often hold large numbers of digital objects, for use in a variety of situations, but efficient Web delivery raises some additional issues:

- What constitutes the 'best' representation for different kinds of objects and purposes?
- What will make content reusable and linkable?
- Why should some content be better retrievable than other content?
- What would constitute a *full rendering* of a(ny) museum object?
- Information not embedded in objects helps us understand them. Such context is recorded:
- in museum and other library publications,
- in registration records and archives,
- in reference sources on the Web.

Linking the digital objects to the additional data requires the metadata and the spatial information to be linked – which encompasses precisely the issues raise in the discussion on 3D container formats in the standards section. All these questions touch on some of the issues raised elsewhere in this document, but are focused by the implications of distributed systems and Internet technologies. For example, the completeness of a rendering touches on the concept of 'accuracy which is fit for purpose'. Similarly, the needs to link to other information will be influenced by whether the digital object is to be re-used or whether its display constitutes delivery of the museum's commitment to the user. An artefact which is to be incorporated in some derivative work might be expected to include additional information, not least the terms of its reuse.

Museums have historically created interpretive labels for each exhibition which are discarded after a single use. When the 'exhibits' are available online the information associated with them takes on more significance and the museum knowledge contained in the 'interpretive labels' will automatically have greater longevity. Integrating this data with Web functions offers the opportunity for enhanced museum services, but raises the question of how to make the knowledge available most usefully.

Accessing resources over the Web is a very personal experience for the user, but of course the opportunity to enhance this experience relies on identification of the user, and further enhancement to take into account the

location of the user at the time of access would also potentially add value for the user. Internet visitors are at least as heterogeneous in character (and disabilities) as those visiting in person and their specific requirements are not as easily identified when personalizing services. All the previous comments on issues of multi-cultural perspectives are exaggerated when dealing with Internet visitors and success in dealing with multi-cultural issues appropriately relies on all the same issue of representation and interpretation of varying cultural perspectives.

There is an important role of Web technologies in the developing area of user-created content. The Web provides an obvious vehicle for linking museums with their communities and for allowing users to add to digital content associated with museum resources in the form of social tagging and contributions to folksonomies (see section 6.5.2). This engagement with the museum will also assist in promoting the accessibility of the physical museum experience – making it less alien for the typical member of the public.

As with all uses of technologies in museums additional research needs to be undertaken into understanding what works with visitors – what generates the sense of engagement and resulting understanding? What technologies work with real visitors? What are effective paradigms for making the message stick? How can monitoring of visitors and their use of interfaces (whether over the Internet or in person) help in evaluating the effectiveness of the visitor experience? Over the Internet there is the additional factor of the degree to which the museum's curation of a collection is mirrored in the relatively unmediated access available over the Internet. Specific control of routing through a Web presence for an exhibition might be one solution to providing curated experiences, but these can be expensive to generate and more evaluation of the user acceptance of constrained navigation is needed. What other modalities of interaction are appropriate both for *in situ* and remote experiences?

The worldwide access to museum collections will also highlight areas of controversy over their origins and the ways in which they may have been collected historically. This may increase pressure for repatriation of some holdings to or restitution to indigenous communities. The alternative of virtual or digital repatriation may serve some purpose, but what technologies would be involved and how would assets be managed?

Finally there are the issues of the business models involved in providing Web access. What are the most appropriate business models for museums offering Web access, to enable them to stay in business? Open content may be desirable for the visitors, but how do museums stay in business? Can museums realistically augment their collective return-on-investment by adopting standard data and architecture today? Experience from online publications might suggest that online access to collections would encourage more physical visitors but this hypothesis would need more testing and evidence before it would be an appropriate planning basis for a sustainable and secure future.

6.7 Information systems for CH monitoring, risk assessment and damage prevention

There are many negative impacts on standing heritage structures and subsurface archaeological sites due to economic, social and environmental factors and, indeed, the number of recognized monuments and sites in danger is increasing (cf. ICOMOS *Heritage @ Risk* reports). While the impact through neglect, vandalism, armed conflict, etc. certainly cannot be overlooked, in the following we primarily concentrate on impact through climate change and natural disasters as well as large development works. Implementation of enhanced or new ICT systems could help to prevent, or at least limit, damage to cultural heritage, though this also requires improvements in the access to, and interoperability of, relevant data sources.

Impacts of global climate change

The Atlas of Climate Change (October 2006) highlights many endangered cultural heritage sites. To provide but a few examples: The monuments of Alexandria, including the 15-century Qait Bey Citadel, are threatened by coastal erosion and the inundation of the Nile delta region linked with climate change; in Scotland some 12,000 archaeological sites are thought to be vulnerable to erosion and sea-level rise, including medieval salt workings in Brora, Sutherland, an Iron Age site at Sandwich Bay, Unst and a Viking site at Baileshire, north Uist; with respect to loss of cultural resources through flooding in Europe, the Czech Republic is highlighted as one vulnerable region among several others (cf. Dow and Downing 2006; UNEP 2006/53). The atlas has been compiled by researchers of the Stockholm Environment Institute with assistance from the United Nations Environment Programme (UNEP), and builds on a welter of newly available and ongoing studies by researchers across the globe, including members of the World Heritage Committee and UNESCO's World Heritage Centre.

The World Heritage Centre together with its Advisory Bodies and a broad group of international experts has also prepared a document, *Predicting and Managing the Effects of Climate Change on World Heritage* (World Heritage

Centre 2006), which reviews the potential impacts and suggests measures such as monitoring and vulnerability assessment, definition of appropriate adaptation measures, and enhancements in the sharing of knowledge and collaboration among stakeholders. Furthermore, it should be noted that the impact of global climate change has become an important shared theme of several International Scientific Committees of ICOMOS (e.g., the Committees on Risk Preparedness, Polar Heritage, Earthen Architectural Heritage and others) (cf. ICOMOS-US 2007).

Required systems and data sources

The increasing impact of global climate change on natural and cultural heritage sites large and small and the need for monitoring, risk assessment and proactive damage prevention have made the capability to integrate, process, visualize and analyse environmental data sources a matter of urgency. Such sources for enhanced heritage management systems could come from in-situ sensor networks (see section 6.8) that capture a stream of relevant data that is both spatially and temporally referenced, thus providing up-to-date information as well as creating a more detailed record for analysis and decision-making. Also the integration of results from a number of predictive computer simulations would be beneficial. For instance, when floods devastated the Elbe and Danube basins in August 2002, the European Union's Joint Research Centre (JRC) delivered daily forecasts of water levels based on a simulated computer model it had developed. This model has since been further refined and can now predict flooding four to 10 days before it occurs (cf. EC 2004a, 19).

Of particular interest also would be to make use of remote sensor data and imagery for the monitoring of natural and cultural heritage areas and sites. UNESCO and the European Space Agency (ESA) in October 2001 established the 'Open Initiative on the Use of Space Technologies to Support the World Heritage Convention', which also has found the support of other space agencies, space research institutions and private companies (UNESCO 2001). Recently, UNESCO and the International Astronautical Federation (IAF) signed a partnership agreement, pledging support for the UNESCO-ESA initiative (UNESCO 2007).

The initiative focuses on the World Heritage sites that are classified as being in danger. It is also hoped that earth observation will contribute significantly to the enforcement of international rules, to better define local–national legislation and facilitate the making of planning policies, in particular in developing countries. There also have been continued efforts by the NGO Eurisy (Paris) to propagate the use of space technologies in CH preservation (e.g., the conferences (co-)organized in Strasbourg 2002, Beirut 2003 and Mexico 2005).

It should be noted that the use of satellite and aerial imagery is not limited to large cultural landscapes and heritage sites, and that a combination of geo-information systems and tools for survey and documentation work on the ground will be required for monitoring and decision-making in specific situations (see section 6.8). As Mario Hernández from UNESCO's Remote Sensing Unit notes:

> "New high-resolution images available (for example Ikonos and/or Quickbird) enable now the monitoring of small cultural sites from space. However, earth observation is not enough, conservation actors are intensively using GPS on the ground in order to document the archaeological sites with extreme detailed precision. Once all this information is put together, conservation experts are using larger satellite image coverage (example SPOT and or Landsat) in order to situate the archaeological site in its overall cultural landscape" (Hernández 2005).

Systems for CH management tasks related to infrastructural development

The need for enhanced CH management systems also is evident with respect to critical tasks in regional and cross-border infrastructural development, e.g., with respect to pan-European transport corridors, new high-speed international connections or large regional development projects. Easy and integrated online availability of CH-related information can help administrators, planners and contractors to take well-informed decisions that reduce unfavourable impacts of economic development on the cultural environment as well as allow for working more cost-effectively.

For example, a main theme of the 36th Annual Conference on Computer Applications and Quantitative Methods in Archaeology (Budapest, 2–6 April 2008) was the use of such applications and methods related to large-scale (rescue) excavations that usually precede infrastructural investments and construction works, and during processing and analyzing the huge amounts of data from such excavations. It is emphasized that in Hungary and the neighbouring countries, "90% of all archaeology is concentrated on such rescue excavations. The infrastructural backwardness of EU accession countries has induced large-scale road constructions, railroad reconstructions and greenfield investments".

Evaluation of potential impacts is already implemented or prepared by the legislation of several EU countries, such as in the area of archaeology the UK Planning Policy Guidance 16 issued in 1990, the Loi no 2001/44 of 17 January 2001 concerning 'l'archéologie préventive' in France and the Law no. 109 of 25 June 2005 in Italy. The benefits of online accessibility of existing documentation such as records of previous archaeological investigation and 'grey' literature, now stored mostly in paper format in the archives of antiquity authorities, is very clear. There exist some examples of good practices of digitization and provision of access in some EU countries, for example in the German lands Baden-Württemberg and Niedersachsen. However, much more has to be done to leverage the information depth, interoperability and access to geo-referenced CH information.

The European Construction Technology Platform (ECTP) initiative in their research agenda recognizes the built cultural heritage as a strategic priority and warns, "[A]ction is now urgently needed to preserve it from neglect and poor maintenance, which currently destroys 10% of tangible cultural heritage every 20 years". The ECTP suggests establishing systems for the integrated management of cultural heritage that should "include technologies and systems for monitoring, surveying, documentation, evaluation, sustainable maintenance, public participation, communication and networking of units with cultural and natural heritage territorial values". Integrated CH management should allow for making available all information generated during the study, restoration and maintenance process, support the development of predictive maintenance plans, and improve safeguarding of CH in risk territories. Also among the ECTP's research objectives is "reducing the decay of cultural heritage by 95%" (cf. ECTP 2005, 7, 28–29).

Involvement in the development of European spatial information and monitoring systems

Cultural heritage management organizations will need to be involved in the current development of European information infrastructures to ensure that specific needs of CH are taken into account. Access to and interoperability of geo-referenced CH information could become an important component in the European Union's Infrastructure for Spatial Information in the European Community (INSPIRE) initiative. The Directive of the European Parliament and of the Council of 14 March 2007 (Directive 2007/2/EC) came into force on 15th May 2007.

Furthermore, there is the Global Monitoring for Environment and Security (GMES) initiative, which aims to develop data infrastructure and services for tackling vital environmental and security issues. The services provided by GMES – mapping, support for emergency management and forecasting – will be vital for security, risk management and management of land use and other resources (cf. www.gmes.info).

A few projects have already been funded within the 6th Framework Programme to support the creation of GMES. For example, HUMBOLDT, a four-year project that works to create a framework for geodata harmonization and service integration (http://www.esdi-humboldt.eu). The project is led by Fraunhofer IGD and involves 27 INI-GraphicsNet partners from 14 European countries.

6.8 Distributed and mobile systems for CH tasks

Many of the issues in distributed and networked systems concern generic technologies. However, there are specific issues concerned with the design of system architectures which are suitable for use in supporting the business processes and tasks of the various cultural heritage professionals.

Such processes and tasks, for example, comprise archaeological field work and excavations, monitoring of CH sites for prevention of environmental impacts, and tasks in regional or cross-border infrastructural development that could damage sites (see section 6.7). Data sources for these purposes can come from a variety of sources, such as satellite, aerial and ground-based remote sensing, in-situ applications such as environmental sensor networks, and field data capturing with GPS handheld tools.

The cultural heritage related part of the applied R&D in distributed and mobile systems consists in designing and implementing CH-specific components on the required variety of platforms and using communications protocols that follow agreed standards for cross-referencing and sharing cultural heritage data. Also, capability of maintaining and extending associated provenance etc. whilst extending the information base is among the basic requirements of the CH sector.

Thus the challenges basically concern the integration and interoperability of data, coupled with the implementation of rich functionality which implements CH requirements (e.g., recording of excavation data: positional information; contexts; textual descriptions; images, etc.) on ICT resources which in field work will often comprise less-capable hardware (e.g., next generation PDAs).

Hence, there are specific CH needs with respect to cross-platform systems. Some of these needs might be implemented on mobile devices interfacing to applications implemented over appropriate GIS technologies.

Applications for networked site monitoring and archaeological work in the field

There is a need for leveraging data capture, integration of data from multiple sources, and accessibility through CH management systems for purposes such as site monitoring. The last decade has seen huge progress in enabling sensor-based data capture and networking technologies, though the opportunities provided by this progress have not been fully realized so far.

With respect to sensor networks, sensors, small operating systems and data processing devices are becoming ever more effective and cheaper, short-range radios are consuming less power, and multi-hop networks are expanding from small local to larger areas. There is a trend towards ever smaller components (e.g., wireless 'smart dust' of one cubic millimetre) as well as more powerful sensors, higher-level operating systems services, mixes of radio technologies, and wide-area networks connecting sensor networks in large-scale deployments (Hart and Martinez 2006). With respect to solutions that attempt to integrate data from a wide range of sensor types the OpenGIS' Sensor Web Initiative and their already available (candidate) specifications should be noted (OpenGIS Sensor Web Enablement WG, Web site; Reichart 2003).

Alongside the possible much wider use of sensor network applications, there also will be a continued need for human data capture that could benefit from smart, GPS-enabled mobile devices (e.g., for field data collection). Furthermore, geo-spatial data could become an integral part of many more cultural heritage tools and services, through rather simple solutions such as GeoRSS (e.g., GeoRSS GML, which also supports coordinate reference systems other than WGS84 latitude/longitude; cf. http://georss.org).

Regarding archaeological fieldwork and excavations, it is widely understood that a higher level of standardization and more effective technical support would be beneficial. At present, several projects aim at providing practical solutions to these issues, among them the Virtual Research Environment for Archaeology (VERA), a UK JISC funded project (04/2007–03/2009) directed by archaeologists from the University of Reading. FieldMap, a handheld GIS application, already enables rapid collection and sharing of archaeological and other data in the field, and is being further developed for a wider range of CH uses (Ryan 2005).

Another important strand of technological development in this area is that of mobile versions of CH-orientated recording hardware (e.g., mobile light studio from the Catholic University of Leuven).

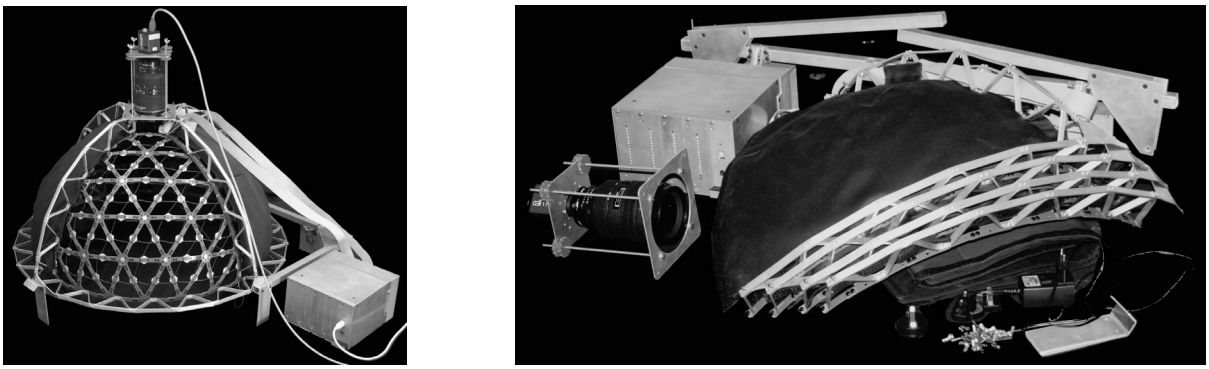


Figure 6.16: Mobile light studio (a) assembled and (b) dismantled for transport

Integration through GIS applications

With respect to Geographic Information Systems, Web GIS applications are becoming the dominant form of working with ever more integrated data and services. Also, 'true' 3D-based applications are expected to become available in the short to medium-term for the purposes of practitioners (Abdul-Rahman et al. 2006; Peng and Tsou 2003; Zlatanova and Prosperi 2005).

Desktop GIS applications that make use of standard Web browsers are allowing researchers to easily access and examine data layers, perform spatial and attribute queries, etc. Available GIS systems comprise commercial products such as ESRI's ArcGIS, MapInfo or Manifold as well as established open source-based systems, such as Quantum GIS or GRASS GIS among others (cf. www.freegis.org). With respect to geospatial data exchange

standards the open specifications of the OpenGIS Consortium (http://www.opengeospatial.org) are ever more widely recognized as important in enabling interoperable Web GIS as well as location-based services.

Most uses of GIS systems in CH centre on purposes of documentation both on the national/regional level (e.g., national monuments records) and the city level (e.g., for providing a data layer for archaeological sites), whereas GIS-based monitoring systems are rare examples. For example, the 'Living with Heritage' project (2005–2009), managed by the University of Sydney's Archaeological Computing Laboratory, aims to create such a system for the greater Angkor region to track, visualize and compare change over time at differing scales (http://acl.arts.usyd.edu.au/angkor/lwh/).

A major shortcoming of most GIS systems is that incorporation of a variety of models (e.g., environmental, socio-cultural, economic), complex spatial analysis taking into account changes over time, real-time collaboration, virtual environments and decision support are often limited. Applications that provide enhanced functionality in these areas are not yet within the reach of most projects.

Recommendations for research and development projects in this field, which probably will have a **short-term perspective**, include:

Leverage GIS-based CH management through model-driven approaches: Most current generation GIS-based CH management systems are not equipped for purposes of real-time monitoring, risk assessment and decision-support for damage prevention. To realize such systems there is a need to get beyond the current 'data-to-layers' approach towards 'data-to-models' and 'data-to-decision'. With respect to environmental impact, this would require the development of appropriate dynamic simulation models as well as the incorporation of regular streams of relevant environmental data sources (including data from local sensor networks; see below). Targeted research into model-driven approaches to CH management would also be beneficial with respect to proactive measures in regional development and tourism management.

Investigate the usefulness of sensor networks in CH monitoring: The monitoring of larger CH sites could benefit from making use of sensor-based data capture with multi-hop network technology. Such sensor networks would capture and transmit data relevant for real-time monitoring and analysing environmental as well as CH site visitor impact and decision-making on preventive measures.

Leverage capability of mobile devices for field data collection: Field data collection with mobile devices could be leveraged through:

- consolidation of the current proliferation of 'home-grown' tools developed by many research groups, including the identification of innovative features;
- development of a standardized driver architecture for the latest generation of survey instruments and making more readily available APIs;
- improvements in the interoperability of recording tools, in particular of surveying and geophysical instruments.

Develop highly effective, integrated ICT tools for rescue excavations: The required speed in capture, collation, and metadata creation for the heterogeneous data sources of rescue excavations necessitates more effective ICT support in the framework of a highly standardized excavation process. The ICT support should comprise:

- a robust system of hardware and software components that allows for wireless, mobile and Internet computing during field campaigns;
- high integration of the tools used on-site, e.g., coupling of GPS handheld devices with other equipment such as Total Station;
- parallel use of content upload to a central (on-site or remote) repository and metadata creation for the data sources (e.g., textual documentation and numeric data, topographical and stratigraphical data, photography, video and 3D data);
- tool support in the creation of descriptive data about finds (e.g., CIDOC Core Data Standard for Archaeological Objects);
- semi-automatic creation of structural metadata about the resources and their inter-relationships, e.g., METS (Metadata Encoding and Transmission Standard) documents;
- rapid integration of find data and geophysical data with maps, 3D stratigraphy and GIS layers, including different scales for structural analysis.

3D data capture technologies in the field: It is understood that on-site 3D data capture technologies have yet to demonstrate a clear value to the excavation process on many site types. However, they may be useful for recording the find's location in context and relative to other finds (followed by scanning of individual artefacts under controlled conditions in the laboratory at a later date).

6.9 Mobile location-based, context-aware and ambient intelligence applications

Mobile applications are highly relevant to the tangible cultural heritage sector for providing information services to visitors to archaeological sites, monuments, historic town centres or interesting places of a regional cultural route. In this context a service will not only deliver general purpose information, but will focus on information that is relevant to the particular place and cultural interests of the visitors. Therefore, the service must be capable of locating the user (location-based) and providing the information adjusted to the context of use (context-aware).

Most current approaches in mobile, location-based services are based on GPS location, GSM triangulation via cell towers, and WiFI solutions to determine the user's position (an overview of these and related approaches is provided in Ross et al. 2005, 162–167). Technical limitations of standard mobile devices with respect to CPU, memory, display size, and battery power have so far allowed only rather simple location-based information service solutions.

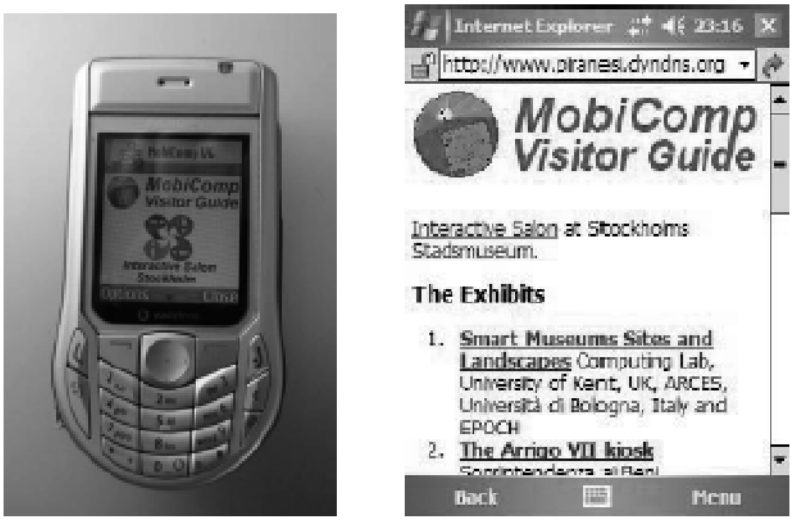


Figure 6.17: MobiComp application for the Interactive Institute, University of Kent and University of Bologna

With respect to the cultural content delivered to the mobile device, predominately images in combination with short descriptive text have been used, which required much engineering for a dynamic content customization according to the technical requirements and constraints of mobile devices. Wireless platforms of 3.5 and 4G can stream Internet radio to mobile devices, though such location-based cellular radio implementations are expected only in the next few years.

The use of 3D content in mobile applications has been limited so far as the first generations of mobile devices had insufficient computational power to support real-time 3D graphics. More powerful devices equipped with special graphics accelerators will allow for making wider use of mobile 3D content (cf. Burigat and Chittaro 2005, for a demonstration of location-based visualization of VRML models in GPS-based mobile guides). New generations of mobile devices also allow richer interaction with animated avatars.

Schwinger et al. (2005) have carried out an in-depth analysis of nine mobile tourist guides that use a map-orientated interaction paradigm and have some adaptation capability according to the technical environment (e.g., different devices, network availability, etc.) and stated interests of the users (COMPASS, CRUMPET, GUIDE, Gulliver's Genie, LoL@, MobiDENK, m-ToGuide, PinPoint and Sightseeing4U). Among their findings the following may be most noteworthy:

– It is not easy to strike a good balance between thin and thick clients;

– Incorporation of content from several sources is rare;
– Dynamic adaptation of the service (e.g., according to network availability, changing user context, etc.) is seldom realized;
– There is very little consideration of tourism as a group-based social activity.

The authors conclude that there is a need for comprehensive context models that allow for a better adaptation of mobile services to the local context of use. Indeed, the context-awareness of mobile applications has often been limited to using only GPS positioning, type of device and network access, and a stated information interest of an individual user to adapt the content delivery. This allows the identification of points of interest that are in the vicinity of the user's location and the delivery of related content.

Enhancements in context-aware mobile delivery can be achieved based on a more precise tracking of the user, which requires some additional positioning facilities (e.g., infrared or Bluetooth short-range radio-frequency beacons), and a dynamic adaptation of the application to the behaviour of the user. For this adaptation the application would make use of, besides a continuous position tracking, an initial user profile and learn from interactions with the user, e.g., what has the user seen and what were they interested in before (in the environment and the delivered content), what is he or she looking at right now? etc. For example, researchers from the Limburgs Universitair Centrum (Belgium) have implemented a prototypic system at the nearby open air museum Bokrijk that makes use of a PDA with GPS and Bluetooth beacons to locate the user and provide information about objects on display (Luyten and Coninx 2004).

Current location-based mobile services are predominantly single-user-based while the visitors to CH sites are often families or groups of students. Usually they do not only want to experience and learn something about the site, but as much want to relate to each other through communicating ideas they have about the site, objects on view, etc. Applications that support this could also learn about such groups' behaviours, identify what is popular among user groups, and adapt the information provision accordingly.

There have been a large number of mobile application projects that explored group-based interaction in indoor and outdoor CH environments. Typically, such projects have been implemented based on a games-based approach with an educational focus. Some examples are the CICERO project at the Marble Museum of Carrara in Italy (Laurillau and Paternò 2004), the VeGame developed for the city of Venice (Bellotti et al. 2004) and ARCHIE at the Gallo-Roman Museum Tongeren in Belgium (Luyten et al. 2006).

Considering the effort implied in the development and trialling of such solutions (cf. the overview by Raptis, Tselios and Avouris 2005), there is a clear need for design, programming and other support through state-of-the-art application development frameworks. Such frameworks will be even more important with systems that aim at a higher context-awareness and reasoning capability in setups that combine a variety of mobile and distributed sensing and computing technologies. These frameworks would benefit from collaboration and the prior experience of groups working in e-learning.

The robust MobiComp application development environment has been created with contributions of Researchers from EPOCH, and further developed in the EPOCH supported CIMAD (Context Influenced Mobile Acquisition and Delivery of CH data) project as a framework for 'smart' CH environments that support a wide range of mobile and distributed systems and tools, from data capture to public dissemination.

However, so called 'ambient intelligence' applications for CH sites still are in the research prototype phase. Such applications use mobile and distributed technologies, with numerous sensing and computing devices distributed throughout the environment. These are small, wirelessly networked devices that can share data among each other and communicate with the visitor. While some devices are visitor-centred, others, such as embedded sensors, may form a monitoring system that collects, analyses and informs the site management about environmental conditions – temperature, humidity, vibration – around the exhibits. Thus, damage through environmental or visitor impact may be prevented, for example, by routing visitors away from areas that already are or may shortly become over-crowded.

Among the main challenges or such environments are continuous tracking and servicing of visitors where a number of technologies are competing, context awareness including the understanding and exploitation of individual and group behaviour (e.g., for personalization of content and shared experiences), and physical constraints of the user devices (e.g., battery power, screens in outdoor environments). No wonder that it has been found difficult to further develop prototypic installations developed within research projects into solutions that work in practice, and useful developments such as specialized sensors for orientation have remained within the research environment or shown limited exploitation in sites and museums.

Recommendations for research and development projects in this field, which probably will have a **medium-term perspective**, include:

Exploit new generations of mobile devices for interaction with 3D content and avatars: New generations of mobile devices with higher storage and computational power, better displays and graphics accelerators will allow for exploiting high-value CH content in location-based services. Applied research should focus on the opportunity to provide richer user experiences through 3D visual content with educational information and interaction with historic avatars.

Develop self-learning systems that allow for dynamic provision of content and guidance: Capability to personalize location-based and context-aware services for CH routes or larger sites has remained rather limited. Leverage in this capability will require a dynamic adaptation of the provision of content and guidance according to the user's orientation, behaviour, and shifting interests in response to local conditions. Research on such self-learning systems that capture and analyse a multitude of different data during the interaction process could lead to a new generation of truly personal mobile guidance and storytelling, also positively challenging the visitor to explore and gain a deeper understanding of cultural heritage places.

Further explore group-centric applications for shared cultural experiences: While visitors to CH sites are often families or groups of students, current location-based mobile applications are predominantly single-user-based or allow for only limited interaction among the visitors. Future applied research and development should focus more on applications that support collaborative exploration of and learning about a site. Results from prototypic games-based and other group-centric approaches should be examined to identify perceived shortcomings in the support of group communication and collaborative access to, and manipulation of, content due to technical limitations. Furthermore, capability of systems to capture and analyse group behaviours in specific environments and with different kinds of content will be of particular interest. This research should be cross-fertilized with research on adaptive e-learning paradigms.

Develop smart, ambient intelligence environments with a perspective to standardize applications for visitor experiences and site management: Ambient intelligence environments can allow for enhancing visitor experiences as well as novel ways of managing CH sites; however, there are still a number of technical obstacles that impede the realization of more complex environments that could deliver the envisaged benefits. While these obstacles may be overcome within a few years, a wider deployment in the CH sector will require developing standardized applications, based on software architectures and sensing and computing units that are easy to implement and manage. Of particular interest will be applications that allow for both visitor support as well as new ways of site monitoring and other CH management tasks.

6.10 Augmented reality applications

Augmented Reality (AR) applications combine real and virtual scenes (2D or 3D visuals) and other information in the user's perception of the environment. This combination of real with virtual elements distinguishes AR (also often called Mixed Reality) from virtual simulations that deliver an entirely computer-generated interactive environment. AR applications are of high relevance to tangible cultural heritage because they allow for augmenting the perception of artefacts that are presented in a museum exhibition or outdoor place such as an archaeological site or monument.

In a scenario of a future CH information landscape, applications would offer location-based AR services that provide visitors with cultural information layers for views, places and objects. For example, a visitor mobile phone could contain a binocular type of display to which stereo images are sent. The visitor is in an archaeological area, though there may not be a public site or museum. The visitor receives stereo images of virtual reconstructions that augment his or her perception of the area. Or, at an existing site, the view is used as an overlay to the remains of a historic building the visitor is studying. Furthermore, applications like this will provide not only visual augmentation but also narrative content (text, audio) and interesting related visual content (e.g., historic images).

A number of AR applications have been developed for the presentation of cultural or natural history objects in museums using projection technologies and special glasses, for example, the stereoscopic display system Virtual Showcase (Bimber et al. 2003). The technical problems of such indoor, highly controllable applications are already well understood, so that a stronger focus on R&D for outdoor applications is to be expected. Indeed, such applications pose particularly difficult problems with respect to user position and orientation tracking, display technology, content rendering and alignment, changes of lighting conditions, and a number of other issues (e.g., cumbersome current equipment in need of miniaturization).

The combination of real and virtual scenes in mobile AR requires see-through displays, which can be either video or optical see-through (for evaluation of a number of HMDs see Bernatchez 2007; Boger 2007). Video see-through head-mounted displays (HMDs) are significantly more widely used than optical ones due to availability and calibration issues. Other solutions such as a flip-down screen on which a tiny laser paints a virtual image (e.g., a Microvision monocular product) or video see-through cell phone applications (e.g., see Moehring, Lessig and Bimber 2004) do not allow for a full AR experience.

In the field of cultural heritage AR only a small number of R&D projects have been carried out, most notably the EU FP5-IST projects Archaeoguide and Lifeplus. The Archeoguide project (05/2000–10/2002) produced a mobile AR guide for outdoor archaeological sites including overlays of virtual reconstructions. The guide was trialled at Olympia, Greece. For tracking the AR device data from a GPS receiver, a digital compass and real-time video-processing was used. Based on the calculations of the users' position, orientation and viewing angle the reconstructions could be appropriately rendered on the display of the viewing device with respect to scaling and placement (Vlahakis et al. 2003).

The Lifeplus project (03/2002–11/2004) explored the narrative design in the combination of real scenes and realistic 3D simulations (plus computer-generated sounds) of humans, animals and plants. Novel techniques and algorithms were used for character simulation including cloth and hair, facial emotion software for realistic expressions, and artificial life algorithms for behavioural animation. A HMD with camera was employed and special software created to identify the display location and movement and to render the virtual content on it.

Within Lifeplus, researchers from MIRALab (Geneva) and VRlab (Lausanne) employed augmented reality technology at Pompeii in the tavern of Vetutius Placidus to realize scenes with five animated historical characters re-enacting a short story based on a scenario created by archaeologists. This involved dialogues between the five characters, object manipulation, virtual human body and cloth animation and facial expressions according to each individual personality and emotions. The visitors were equipped with HMD (an i-glasses product from i-O Display Systems) and could modify their position and orientation within the designated area (Papagiannakis et al 2005; Ponder et al 2003).

A major general insight of the Lifeplus project is that in AR applications presence (the feeling of 'being there') as well as believability (the level of realism in the interactive environment) must be achieved. If real-time virtual characters are introduced, presence is strengthened, but believability lags behind, due to lack of interaction between the visitors and the virtual characters (Magnenat-Thalmann et al. 2005).

A major future step in AR applications for cultural heritage experiences would be to develop applications that allow for 'social awareness' of the virtual humans and interactions between the real users and virtual characters. In addition, while current applications offer only individual viewing of AR scenes, future applications should allow for sharing of, and communication about, AR experiences among users.

The Lifeplus researchers also suggest that there could be considerable synergies with disciplines such as semiotics, psychology and physiology, which could help establish a theoretical framework and empirical evidence with respect to experiences of presence and believability.

Recommendations for potential **long-term research themes** in augmented reality applications are:

Develop further storytelling frameworks for interactive AR applications: There are still limits in current AR technology for simulating scenes of detailed virtual environments and humans within real places (e.g., with respect to consistent lighting), which, however, are expected to be overcome through fine-tuning of rendering, registration, and animation solutions. Major advances in AR applications should be sought regarding the conceptual and technical frameworks for storytelling that involves interactions with historic characters. This would require 'social awareness' of the virtual humans, i.e., capability to identify and respond to statements and gestures and mimic the expression of visitors.

Investigate feasible approaches to 'open world' interaction with virtual characters: While it may be relatively easy to realize simple interactive sequences with virtual characters, a hard R&D challenge is open, not predefined, interaction. This would require some 'open world' artificial intelligence on the side of the virtual characters or, rather, the system that controls their interaction in response to identified input from the user such as statements or gestures.

6.11 Long term preservation and upwards compatibility

The selection of technological topics of the Research Agenda largely corresponds to the strands of research that have been present within EPOCH. They did not include research in the field preservation and curation of digitized and born-digital cultural resources. However, it will be appropriate to include some brief notes on the high relevance of research in this field.

There is increasing recognition within the ICT community of the different and extreme requirements placed on archival systems by the cultural heritage domain. Archival in ICT environments has rarely meant preservation over a period of more than perhaps 10 years. Recently the advent of several important initiatives for technologists (e.g., the opening and subsequent closing of the Boston Computer Museum and amalgamation into the Boston Museum of Science (MoS site) and the 60th anniversary of the code-cracking operations at Bletchley Park in the UK with the desire to develop replicas of the processing engines used there (Sherriff 2004) has led to an interest in the curatorship of computers and their associated information.

However, any of the timescales involved here pale into insignificance compared with even the shortest of timescales involved in cultural heritage and highlight the lack of long-term preservation in the world of hi-tech. After all, an artefact is not technically considered an antique until it is 100 years old and the age of archaeological heritage is more commonly measured in hundreds or thousands of years.

In these circumstances it is not surprising that the archival regimes developed for the computing industry have a number of shortcomings when the archival of digital cultural artefacts is being considered. Obvious problems are concerned with both the physical media (both durability and the obsolescence of the equipment capable of reading it) and the logical formats (knowledge of the data encodings, file formats, version control and the software maintenance of systems for interpreting them).

The following is a list of major sub-areas of concern:

- Formats (standards, encodings, metadata, provenance, paradata);
- Logistic processes for long-term preservation (media, regimes, security, resilience, redundancy);
- Legal frameworks (IPR, copyright, licensing, royalties, grey literature/documentation, metadata rights, collected works, derivative works, orphaned works, etc.);
- Business models for long-term preservation (responsible authorities, legislative requirements, secure financial basis, etc).

The Digital Preservation Europe project, established under the 6th Framework Programme, is acting as a forum for research in this area. The project has also developed a research roadmap in digital preservation (DPE 2007).

There are many ongoing and recently-started new initiatives on specific topics in digital preservation and curation. One example is the ‘Big Data’ project of the Archaeology Data Service (UK) on large volume content and data sources that originate from archaeological projects (ADS 2007). There are also a number of recently-initiated projects in the EU FP7 program with relevance in this area – notably CASPAR, but also PLANETS, LiWA, PROTAGE and SHAMAN. This last project is intending to investigate the use of intelligent agents in decision making about long-term preservation requirements. The University of California at Berkeley’s project ‘Media Fault’ has also demonstrated the use of intelligent tools in determining effective long-term preservation strategies for collections.

7 Standards and interoperability

Agreed standards are an essential part of reaching the vision of an integrated world of cultural heritage knowledge. The EPOCH project has worked with three distinct areas of standards:
- Metadata standards;
- Technical infrastructure standards;
- Charters and guidelines.

7.1 EPOCH approach to standardization

There is considerable work to do to achieve genuine adoption of standards which maximize the opportunities for creating interoperable systems with rich functionality, capable of delivering on the potential benefits of ICT applications to cultural heritage.

There are several distinct but overlapping phases in standardization
- Achieving agreed definitions;
- Gaining adoption with defined interoperability with other standards;
- Initial deployment in real applications as 'proof of viability';
- Implementation with a critical mass of applications/data.
- A huge amount of effort is needed to achieve agreement between a representative international group of experts on the specification of any standard. This is in part because standards are defined in natural language (for technical standards, usually in English), which is inherently ambiguous and open to interpretation. The process of standardization consists not only in agreeing on the functionality to be achieved but also of ensuring that the functionality is described unambiguously.
- The danger in seeking a fully considered standard is that the time taken to achieve agreement may be so long that the technologies it addresses, or the need it seeks to address, have been bypassed in the interim. Conversely a widely-adopted standard with limitations may well continue to be used in both legacy and new systems for the degree of interoperability it offers, even when there are newer standards of much greater potential because the newer standards do not initially bring with them the same widespread adoption.
- In some application areas, communities have taken general-purpose standards and defined application-specific profiles to agree on how a particular standard will be used in that application area. This profile might include specification of how optional parts of the standard will be used, what parameter ranges are included, and which encodings of the basic functionality are mandated. A metadata application resulting in the combination and re-use of different metadata element sets is also sometimes referred to as an application profile (cf. Dekkers 2001).
- Figure 7.1 summarizes the EPOCH approach to contributing to work in standards, which involves engaging with the cultural heritage community and disseminating knowledge and training in the use of standards. In addition, the EPOCH standards team examines the best specialist approaches to deploying appropriate standards. In return, the community provides feedback on any specific shortcomings, which are relayed to the standards community.

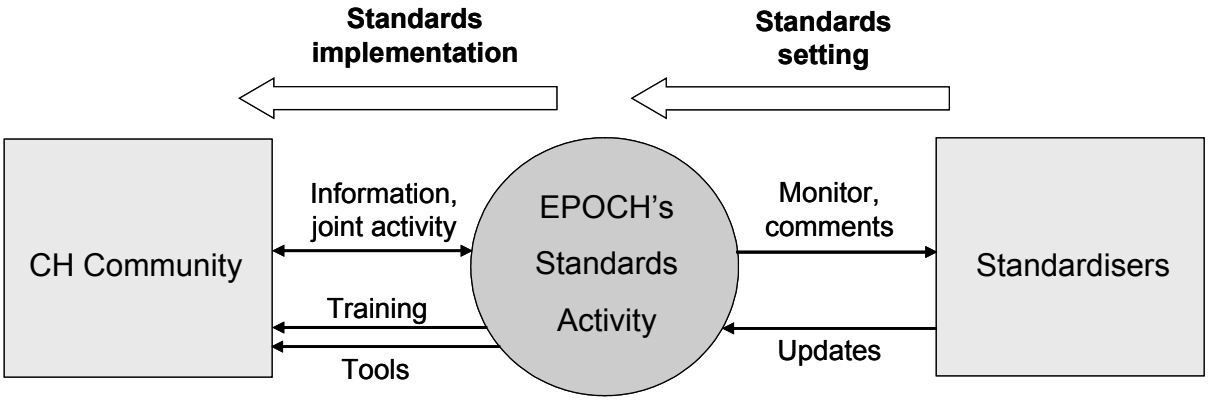


Figure 7.1: EPOCH approach to contributing to work in standards

The EPOCH Deliverable D4.2.1 (Niccolucci 2006a) gives an overview of current standardization activities and issues in standardization that are of particular importance in the technological areas covered by researchers in EPOCH. Although recent years have seen the development of standards targeted specifically at the definition and processing of cultural heritage data there is still a great deal to do before the vision of applications accessing widely distributed, interoperable, digital, cultural heritage resources is realized.

Generally it is felt that there is a lack of accepted all-European documentation standards, which only exist in some areas, for example libraries, whilst no trans-national agreement exists in most other areas, such as archaeology or monuments. This adds to the difficulties of multilingualism and the lack of multilingual thesauri, which cannot be easily overcome by technology alone. The effect is to jeopardize digitization efforts, and it has been underestimated in establishing digitization policies, as far as they just rely on 'core' metadata, which actually guarantees very little information about the cultural content.

There are many future research requirements in different aspects of standardization, including entries relating to the tools required to assist in standardized encoding of cultural heritage data. In this regard technology may offer substantial support to the unification of documentation by providing tools for mapping local, national or de-facto standards to each other or to an accepted international standard. Although requiring a consistent effort, mapping appears in fact to be the only way to overcome the idiosyncracies of cultural heritage professionals with regard to standardization and to deal with the huge amount of digitized legacy data. As shown by preliminary activity in this field, mapping is not a straightforward exercise and the technological aids must be able to cope with a number of complex and intriguing cases.

7.2 Metadata standards

There is a wide range of descriptive, structural and administrative metadata standards applicable to cultural heritage institutions — from item- to collection-level descriptive standards, from digital preservation to emerging multimedia specifications. (The Canadian Heritage Information Network's Web site provides an excellent overview of standardization efforts at various levels (CHIN).)

Among the most significant recent achievements has been that of the finalization in December 2006 of the ISO version of the CIDOC Conceptual Reference Model, which is a reference ontology for the interchange of cultural heritage information (ISO 21127:2006).

The CIDOC CRM is the culmination of over 10 years' work by the CIDOC Documentation Standards Working Group and CIDOC CRM SIG. This work has been conducted with the aim of establishing

> "…a common and extensible semantic framework that any cultural heritage information can be mapped to. It is intended to be a common language for domain experts and implementers to formulate requirements for information systems and to serve as a guide for good practice of conceptual modelling. In this way, it can provide the 'semantic glue' needed to mediate between different sources of cultural heritage information, such as that published by museums, libraries and archives" (CIDOC Conceptual Reference Model, home page).

Early work in investigating the mapping of CIDOC-CRM concepts to particular working practices has shown areas where small extensions (which are permitted in the standard) would enhance the compatibility with national classification systems and hence the interoperability of applications using the standard with legacy systems based on national standards. Other work on adoption of the CIDOC-CRM has suggested the desirability of an extension to accommodate the recording or the processing history and other provenance associated with a digital artefact.

CIDOC-CRM is in the relatively early stages of adoption with significant numbers of projects adopting the standard and working through the teething problems in operating with other systems. CIDOC-CRM is being introduced against a backdrop of considerable investment in metadata standards in the Digital Library community.

Much of the metadata standardization in use in this community is based on or mapped to the work of the Dublin Core Metadata Initiative (DCMI) and their DC Library Application Profile (DCMI Library Community Web page). The Dublin Core also underpins work in a number of other communities and has been the target of mappings developed in other standardized environments. For example the Library of Congress has defined mappings from their systems to and from the Dublin Core Metadata Element Set (ISO 15836). The Library of Congress also uses the METS (Metadata Exchange and Transmission Standard) as an interchange standard for metadata resources.

As the name implies, the Dublin Core, however, only seeks to address a core set of elements and is intended to provide standardized definition of the elements likely to be included in the core metadata of library entries. For example, Dublin Core is the announced basis for the MICHAEL project's exchange of museum catalogues to enable European museums to exchange information about their collections (Caffo 2006).

Indeed, interoperability of information is often obtained by reducing it to Dublin Core (DC). However, DC was devised for different goals, and does not preserve the richness of existing museum repositories. Hence many institutions have chosen to use so-called 'qualified DC' with the result that every 'qualification' is going to be different from the others and again no standardization will result. On the other hand, it is apparent that a great deal of the information is the same, under different names, as it pertains to the same domain; so the objective of extending the core of more readily interoperable data to a much wider common set is feasible.

In contrast to the library sector, there is a very high fragmentation in the field of tangible cultural heritage management. This has caused a considerable lack of standardization in the documentation of tangible heritage, for example, regarding archaeological records. In practice, every country, and sometimes each region within countries, has adopted different regulations in this field. This situation impacts on the interoperability of currently available, or forthcoming, digital CH records. There is an increasing awareness of the necessity of harmonizing standards and achieving interoperability.

An initiative involving several national archaeological services to design and promote a tool and guidelines for mapping national archaeological documentation to a common standard has been started by EPOCH in the AMA (Archive Mapper for Archaeology) project. AMA has developed a tool for semi-automated mapping of existing archaeological datasets to a CIDOC-CRM-compatible form. Also an initial set of mappings from a number of currently-used national specifications as well as a guideline for further implementations has been produced.

The CIDOC-CRM approach provides a rich set of relationship encodings and takes into account the requirements of metadata suitable to encode information about artefacts of tangible cultural heritage and their history. There is a simple mapping defined from Dublin Core Metadata Element Set to CIDOC-CRM, but this does not make appropriate use of the potential of the CIDOC-CRM to support functionally-rich applications. To do this requires additional information relating to the primary sources to be encoded. The current major question is whether a sufficient body of effort will be put into generating a critical mass of digital resources with the additional information.

To enable the creation of a critical mass of data requires tools to semi-automatically assimilate and encode the required capture of new data and conversion of legacy metadata. There is also potential for intelligent tools to assist by using language processing technologies to extract metadata from free text and relating multiple sources to establish co-referencing.

7.3 Legacy data and metadata

At several points the discussion elsewhere refers to specific issues to do with legacy data. Whilst these issues are in essence very similar to dealing with the creation and manipulation of digital objects from primary sources, there are different issues too. These issues concern:

– The quality and media of the secondary sources (including legacy digital data);
– The continuing availability of primary sources;

– The relationship between sources.

How do you link secondary sources which are themselves cultural artefacts of significant historic interest? In these circumstances the secondary source becomes primary in what it tells us of the times in which the investigation and recording were carried out and for what it tells us of the people and processes used.

The aspects of the significance of secondary sources are addressed by the cultural heritage sector in non-digital systems. For example, the existence of errors or inconsistencies between primary and secondary sources, or between multiple secondary sources recorded over time is a challenge which exists in any system (digital or non-digital). Do these variations represent accurate recording of changes over time or errors in one or more attempts to document the primary sources?

Recording and representing inconsistent information about a single set of circumstances or facts remains a challenge. By qualifying each of the 'facts' with its attribution ("The archaeologist X believed that Y was true" rather than "Y is true") contradictory 'facts' can be resolved even though the underpinning assertions remain in contradiction. The challenges are related to issues of representing provenance, uncertainty, interpretation and cultural values. The CIDOC-CRM (ISO21127:2006) allows at least some of these aspects to be represented explicitly and recently proposed extensions to the published standard include the capacity to represent the aspects of provenance relating to the development of digital objects.

The aspects which are more difficult to represent in ways that allow search and intelligent computer-assisted analysis concern the values and judgements embodied in the 'facts'. For example, in past documentation of the evidence the cultural professionals of the day would have had to interpret with the information they had available. Clearly information discovered since their reports were completed cannot have been factored in.

In fact their recording would normally include some initial interpretations and be based on facts that we cannot now re-examine. For example, a field archaeologist records contexts which are related to locally observed variations. If something is missed in the initial observation then the raw material will normally have already been disturbed and the experiment cannot be repeated. If the archaeologist interprets a particular pattern in the soil as a post-hole and records it as such, then revisiting the original evidence of soil-type boundaries to decide whether that interpretation is correct is normally not an option.

Legacy data are of significant interest to the (re-)interpretation of heritage sites as well as to scientific history and heritage (e.g., history of research paradigms, methods and practices). Therefore, guidance (including best practices) on how to deal with legacy data, historic material and metadata, particularly in the digitization of such resources, is very important.

7.4 Technical infrastructure standards

Technical infrastructure standards is a term used within the EPOCH project to describe the standards used for the underpinning technologies such as graphics and GIS systems.

The major work to be addressed here is to define the relationship between such standards and the additional information held in cultural heritage collections, encoded in metadata and free text as covered by the standards in the previous section. There is a need to inter-relate the information held in each so that, for example, a real-time interactive display of a virtual reconstruction can draw information on the components of the virtual scene in response to interactions from the viewer.

The EPOCH project has adopted the OpenSG graphics standard for the scenegraph representations of 3D objects and environments. The OpenSG framework for 3D rendering is an Open Source, portable scenegraph system to create real-time graphics programmes, e.g., for virtual reality applications, built on top of OpenGL. Additional standard mechanisms are required to incorporate the links to additional information within the representation of the scene and to provide the hierarchical nested structures implied by the scenegraph structure.

EPOCH has been investigating the use of COLLADA or METS as potential structures to incorporate the mix of 3D geometry and visual properties with links to metadata describing the provenance of the 3D objects. Since objects may be nested one in the other and instances repeated multiple times, the cross-referencing must support nesting and the aggregation of pieces of provenance for the individual components into the collective provenance of a derived work.

At present these considerations remain under review and more research will be required to fully appreciate the consequences of selecting one standard over another. One concern must be that although the COLLADA standard is well supported by industrial backers from the games industry it remains a proprietary standard, whereas METS is based on internationally-agreed formal standards.

7.5 Charters and guidelines

EPOCH work in these areas has focused on four major topics:
- The London Charter for the Use of 3D Visualization in the Research and Communication of Cultural Heritage;
- The ICOMOS Ename Charter for the Interpretation of Cultural Heritage Sites;
- Usability guidelines for interactive experiences.

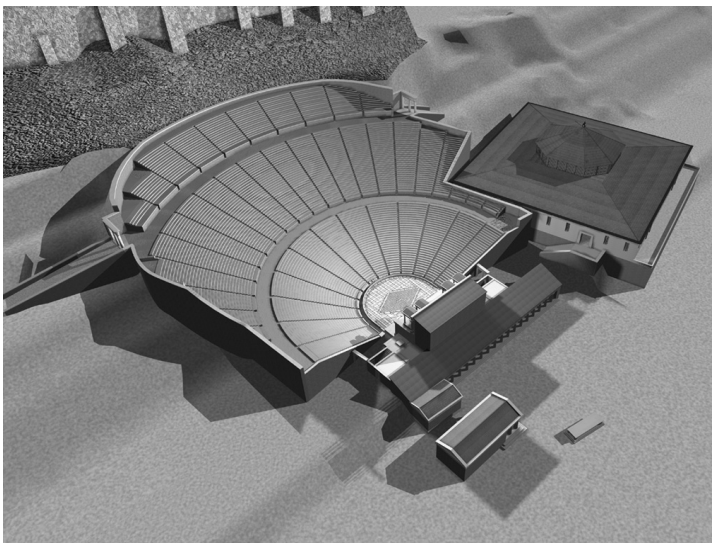


Figure 7.2: Reconstruction of the Greek Theatre of Dionysis (Baker and Beacham 2003)

The London Charter for the Use of 3D Visualization in the Research and Communication of Cultural Heritage

The aim of this Charter is to define the fundamental objectives and principles of the use of 3D visualization methods in relation to intellectual integrity, reliability, transparency, documentation, standards, sustainability and access. It does not aim to prescribe specific aims or methods, but rather to establish those broad principles for the use, in research and communication of cultural heritage, of 3D visualization upon which the intellectual integrity of such methods and outcomes depend. Therefore, at the level of specific subject communities additional guidelines and recommendations about, e.g., technologies, standards, and methodologies, will be needed.

The initial version of the London Charter was presented and debated at the London Symposium and Expert Seminar 'Making 3D Visual Research Outcomes Transparent', which took place on 23–25 January 2006 with an attendance of 50 international delegates. The event was organized by King's Visualization Lab, King's College London, and jointly sponsored by the AHRC ICT Methods Network and EPOCH. The work on the Charter is an ongoing activity, for example, the editorial group and experts from different subject communities discussed refinements on 26 November 2007 at the VAST 2007 conference in Brighton, UK. Also, a methodology to make 3D visualisations based upon the London Charter has been designed under the EPOCH Common Infrastructure activity (Pletinckx 2008).

The latest version of the Charter is available online at: http://www.londoncharter.org

In addition to the background information on the Charter home page, an article is available that describes the motivation for, and development of, the Charter (Beacham, Denard and Niccolucci 2006).

The ICOMOS Ename Charter for the Interpretation of Cultural Heritage Sites

The aim of this Charter is to define the basic objectives and principles of site interpretation in relation to authenticity, intellectual integrity, social responsibility, and respect for cultural significance and context. It seeks to encourage a wide public appreciation of cultural heritage sites as places and sources of learning and reflection about the past, as well as valuable resources for sustainable community development and inter-cultural and

inter-generational dialogue. Although the objectives and principles of this Charter may equally apply to off-site interpretation, its main focus is interpretation at, or in the immediate vicinity of, cultural heritage sites.

The Charter has been developed since 2002 by the Ename Centre for Public Archaeology and Heritage, Belgium (www.enamecenter.org) under the direction of Neil Silberman and has received continued support by the EPOCH project. The Ename Center also maintains the technical secretariat of the ICOMOS International Scientific Committee on Interpretation and Presentation (ICIP; http://icip.icomos.org).

At the 2007 ICOMOS International Advisory Committee meeting (Pretoria, South Africa, 8–13 October 2007) the proposed final version of the ICOMOS Ename Charter was recommended for presentation and ratification at the 16th ICOMOS General Assembly in Quebec in 2008.

The latest version of the Charter is available online at: http://www.enamecharter.org/

In addition to the background information on the Charter home page, an article by Neil Silberman describes the motivation and broader framework of the Charter (Silberman 2006).

Usability guidelines for interactive experiences

An important topic within EPOCH also has been the usability of cultural heritage ICT applications. A survey carried out by the EPOCH teams at the Hypermedia Open Center, Politecnico di Milano, and TEC-Lab, University of Lugano investigated the current usage and most common approaches and practices in usability evaluation methods. Furthermore, the particular needs and expectations of CH institutions have been identified with the aim to provide guidelines for the evaluation of ICT applications that might be widely accepted and effectively used in CH projects. The results have been published in a guideline whose contents have been presented and discussed at EVA 2006. Further work on the guidelines and educational material on usability design and evaluation methods specifically tailored for the CH sector is carried out by the research centres.

Open Access to results of publicly-funded research

Furthermore, EPOCH researchers have emphasized and demonstrated on many occasions the importance of using appropriate ways of sharing research results, such as the Open Access to research data and publications, Open Source software as well as open Application Programming Interfaces (see chapter 3 section 3.7 on background and recommendations).

8 Market background and adoption levels for selected ICT applications

This chapter provides market background on available ICT applications that are considered to have a particularly high relevance for the CH sector. Besides providing insights into these markets the aim is to identify strategies for leveraging the adoption and appropriate use of the applications. The focus is on digital access, presentation and communication.

The first section gives an overview of the current level of adoption of a broader set of applications for providing access to and presenting cultural heritage content. Applications that are already widely used and others that show considerable limitations for uptake in the CH are presented in tabular overviews with a brief assessment of current technical, financial and other barriers to adoption. Moreover, some challenges in the further development and wider adoption of ICT applications in the CH sector are summarized.

The sections that follow take a closer look into three selected fields of applications that are considered to have a particularly high potential for CH presentation and communication. The selected fields are 3D technologies from 3D digitization to Virtual Reality environments, mobile, location-based services, and social software and related Web 2.0 applications for user-generated content.

8.1 Adoption of applications for digital access, presentation and communication

The following tables provide an overview of the current situation regarding the adoption of ICT applications for digital access, presentation and communication and perceived limitations that inhibit their wider uptake.

The assessment of the different applications is based on a presentation of Vassilios Vlahakis from EPOCH partner INTRACOM S.A. Telecom Solutions, Greece, in the Research Agenda workshop at the VAST 2006 conference in Nicosia. INTRACOM is a commercial partner in EPOCH and has participated in several other RTD projects in the EU Framework Programmes and is involved in the development of practical solutions for the cultural heritage sector (in particular, guiding systems such as the ones developed for Olympia, Pompeii and various museum systems).

8.1.1 Already widely used applications

Applications & devices	Short comments:	Current limitations
CD-ROMs, DVDs:	Widely available either with educational, tourist, or scientific emphasis.	None.
Audio guides:	Widely used in major (and smaller) museums and sites, analogue or digital, manual or automatic.	None.
Interactive installations (open-air and museum-based):	Mainly based on touch screens or large projection screens. Their use is normally included in the museum ticket price	True immersive installations are not in wide use. Interactive installations in museums may sometimes feature presence or motion detection.
(Distributed) Digital Cultural Archives:	Proprietary formats or standardized, often not interoperable.	Regarding the database design various schemas and standards are used to enable interoperability. However, as various 'industry' standards have been developed and promoted by the major international museums and CH institutions the widespread adoption of a single standard or the interoperability of the existing ones has still not been achieved.

Applications & devices	Short comments:	Current limitations
Web portals (info provision, event scheduling, virtual museums, etc.):	Individual institution efforts or combined efforts at national/ international level.	None. Some international standardization of portal design could be beneficial.
Web forums, Weblogs:	Less structured and controlled than other media. Free of charge, requiring a simple user registration.	None. Social Software applications are quite simple to implement and can allow for a more personal communication of curators with the museum audience (e.g., through a Weblog) or enhance the work of study teams (e.g., Wikis).
On-line shops (cultural artefacts, souvenirs, books, etc.):	Mainly owned by museums etc; also by specialized companies.	None.
Mobile telephony services for cultural information:	Offered by mobile telephony operators as a basic guide and sometimes linked to on-line ticket booking.	Some examples include location sensitivity, though this is still in the prototyping - evaluation phase

Table 8.1: ICT applications that are already widely used in the CH sector

8.1.2 Applications showing considerable limitations

Applications & devices	Short comments:	Current limitations
Mobile MM guides ('Commercial' on-site use of PDAs, e-guidebooks, etc.):	Featuring a wide variety of functionalities and presentation media. Include manual or automatic operation, location and/or context sensitive, content and/or UI personalization. Range from simple MM presentations to use of VR and AR.	The commercial use of mobile guiding systems is inhibited by the initial investment required (though in medium- to long-term operation they can provide significant revenues to a site / museum through the attraction of additional visitors, sale of souvenirs, etc.) The various installations (mainly experimental) provide a test-bed for further development. Among the main technological challenges are – location awareness where a number of technologies are competing (infrared, Wi-Fi, RFID tags, Bluetooth, ultrasound), – context awareness (including the understanding and exploitation of user behaviour and needs), – on-line access to distributed archives (problems arise from the non-unified standardization of these archives – CIDOC, Dublin Core, CDWA, are some of the standards used), – Digital Rights Management solutions, and – Physical constraints of the devices, in particular, battery power limiting the devices' autonomy. In combination the issues mentioned above also imply limitations regarding the intuitive operation and personalization of the cultural experience

Applications & devices	Short comments:	Current limitations
Wireless MM access and VoIP	Wireless MM access can be achieved by any of the existing wireless technologies. VoIP is used in culture as part of the mobile guides facility in order to group several devices together and support group tours and educational scenarios.	Typical problems include the tedious connection process (common to mobile phone services), the slow data transfer rates as a result of high usage, and the still considerable costs involved. Free services exist though still with limited availability, mainly through Wi-Fi and Bluetooth. VoIP is still limited to systems under evaluation, while it has found a market outside culture for cheap telephony.
Location-based systems:	GPS, infrared, Wi-Fi, RFID tags, mobile telephony cells, Bluetooth, video tracking, and ultrasound are used in decreasing order of frequency. The most frequently used are GPS for outdoor spaces, and infrared for indoor spaces.	All current solutions suffer from limitations of accuracy and ease of use, necessitate line of site (for infrared and video tracking), and incur high costs. The majority of mobile applications still rely on the user identifying his location on a digital plan or taping a code identifying an exhibit or location. More recent mobile phone applications enable their users to take photographs of their surroundings or exhibit of interest and send it to a central server for location detection by image-matching to a visual archive.
VR installations (caves, 3D theatres, interactive panoramic screen installations):	VR systems are used as part of on-site museum installations, or delivered through Web sites and, more recently through mobile guides. VR installations are mainly to be found in larger museums and commercial-entertainment establishments. Usually at extra cost to the normal entrance fee.	The use of VR systems is still rather limited due to the high cost involved in creating the 3D models of objects, buildings, and landscapes. A simpler and cheaper approach to VR is the use of the panoramic view, possibly annotated. They do not provide all the functionalities of VR but they give the opportunity to explore museums etc. without having to visit them and so help disseminate culture.
Augmented Reality systems:	AR systems are currently only seldom used in cultural settings.	There are very few installations and they are mainly for evaluation purposes. This is due to technological limitations (positioning accuracy of the overlaid graphics, quality of the visual effect), availability and ease-of-use of suitable devices, and considerable costs of AR systems.

Applications & devices	Short comments:	Current limitations
Digital Interactive TV and Triple-Play Services	Digital Interactive TV and, more recently, Triple-Play Services are beginning to find their way to the consumer market. Their more common CH use is the transmission of documentaries, mainly through specialized channels. However, the potential of these technologies is huge as consumers can browse and request cultural information from the comfort of their home using nothing more than their television.	Currently these technologies show a limited market penetration, and only a limited range of services is offered, especially regarding cultural content. The high cost of setting the necessary infrastructure can be more easily covered since it will not be dedicated to cultural applications only.

Table 8.2: ICT applications that show considerable limitations for adoption in the CH sector

8.1.3 Challenges in the further development and wider adoption of applications

While the overviews above address mainly technological limitations, in this section we summarize some general challenges in the further development and wider adoption of applications in the CH sector.

Better integration of efforts and synergies between all stakeholders

In many projects a decisive move should be made from isolated research efforts to research that integrates perspectives and knowledge from different stakeholders. For example, the expertise of commercial companies and more advanced CH institutions, e.g.,, from best practice showcase implementations, could often help prototypes that are becoming 'near market' to be demonstrated with some 'market intelligence' and CH usability in mind.

Standardization and process automation

As a core requirement of bringing the benefits of ICT to the CH sector more efforts must be dedicated to standardization. Besides a higher cost-effectiveness of single application development this is of particular importance for the overall infrastructure and application integration (e.g., for pervasive and ubiquitous computing in CH environments).

The success of a wider implementation of CH ICT hinges on a much stronger automation of many processes from data acquisition and metadata creation to support of content authoring (e.g.,, for multimedia or Virtual Reality applications) and database and application management.

Best practices and benchmarks

It should also be noted that for many applications there still exists a considerable lack of available knowledge about best practices and benchmarks (e.g.,, regarding the use and impact of digital services delivered by local, regional and national CH institutions).

Personalization and contextual sensitivity

The capability for providing enhanced personalization and taking into account user contexts (e.g.,, location, user behaviours, needs and interests, etc.) is currently rather limited. Various technical approaches have been explored over the last few years, each showing some shortcomings (e.g.,, with respect to employability, accuracy, ease of use). However, the most critical part to address in the future will be the modelling of the user experience which ultimately determines whether an application is successful and finds a wider adoption in the sector.

Enabling storytelling in and beyond the museum

Michael Danks from Windfall Digital in the EPOCH Research Agenda workshop in Nicosia (2 November 2006) emphazised the importance of supporting CH institutions, particularly smaller local and regional ones, in telling

stories about particular objects that they hold. This would help in better contextualizing their collections and making them more interesting for their on-site and their online visitors.

Heritage story-telling could also benefit much from leaving the boundaries of the museum and expanding into urban places such as squares, railway and metro stations, etc. (see, for example, the projects of Local Projects, a museum and exhibit design firm, http://www.localprojects.net).

Better knowledge about requirements through involvement of institutions and users

It is important to gain much more knowledge about the current and future needs of CH visitors, CH management and staff, researchers and other professionals. This can be best achieved through ensuring participation of users right from the start of a project. Involving users in only final testing of a new application means that their views and needs have not been taken into account properly throughout an ICT development project. In particular, the knowledge of institutions and their staff may be important in overcoming many practical issues in the development of applications. Moreover, their commitment can become the driving force for further developments and ensure the financial viability of all endeavours.

As with many application areas the professionals working in those areas must have ownership of the responsible use of technologies. In this case CH stakeholders must find the right balance between different goals. For example, the conservation of fragile cultural heritage may conflict with the wish to provide better access for the citizen or, choosing to present diversity and richness of CH perspectives may of may not be more appropriate than presenting and interpreting from limited perspectives in order to present clearer messages.

Business models and financial issues

More knowledge is required with respect to various financial aspects of technology adoption and business models for CH ICT applications in general. This includes issues from initial development costs to the total cost of ownership (and sustainability) of certain applications in a museum or CH site.

While benefits of technologies (visitor attraction, improved management of sites, etc.) may be easily communicated, the hard part is to get the cost/benefit equation right. Applications that are in ‘prototype stage’ at heritage institutions will often need a considerable commitment by the institutions and extra funding from governmental agencies that are interested in promoting advanced ICT in the CH sector.

Impact of the fragmentation in CH administration

In many European countries there exists a high fragmentation of responsibilities regarding CH administration and funding. Projects large and small often require commitment from several agencies which results in long project definition phases as well as an uncertain situation regarding available budget. Stakeholders in Cultural Heritage and CH ICT should wherever possible point out what this can mean in regard to the implementation time of new solutions that may be urgently needed (e.g.,, in critical CH management tasks or the preservation of digital assets).

8.2 3D technologies from 3D digitization to Virtual Reality environments

This section takes a closer look into the adoption of 3D technologies in the CH sector. In the last decade, the concept of digital media has evolved from single-content type, mainly related to textual and non-textual data (e.g.,, images, audio or videos) to truly multimedia content, which integrates several types of content. At the same time, the possibility of handling 3D visual content in specialized and non-specialized Internet-based environments has become a reality. Indeed, it seems clear to many observers that 3D on the Web and other platforms will drive a new wave of multimedia content and novel applications. This is exemplified in the recent Metaverse Roadmap’s Pathways to the 3D Web report (Metaverse 2007) and the interest 3D finds in areas such as mobile gaming (Gunnarsson 2005) or mobile navigation (e.g.,, provision of landmarks and terrain in 3D).

8.2.1 Leveraging the collecting and sharing of knowledge in the digitization of tangible cultural heritage in 3D format

The impact of 3D content in the field of cultural heritage is expected to be high as such content allows for:

- increasing the number of tangible artefacts that can be presented and compared in an exhibition, including also the 'virtual repatriation' of some tangible CH:
  - in particular, rare and fragile objects as well as very large objects (e.g., virtually reconstructed individual or ensembles of buildings) can be made accessible to the public,
- 3D shapes offer more potential for interactivity since they can be observed and manipulated from different viewpoints.
- the richness of their representation contains more information about an object than a simple image.
- 3D data acquisition through laser scanning and photogrammetry is already widely used in the cultural heritage sector for purposes of documentation, research, virtual reconstruction and presentation. Also, creating physical replicas of CH objects (e.g.,, busts or statues), archaeological artefacts (e.g.,, carvings) or human remains is gaining in interest (see the examples presented on English Heritage's Heritage3D website and Cooper, LaPensée and Parsons 2006). It is expected that ever more 3D data will be captured and used for a variety of tasks, for example, in area regional and urban regeneration and development planning that has to cope with many other issues in addition to the preservation of CH sites.

Lack of information on progress in 3D digitization

Despite the perceived importance of 3D content in the CH sector, unfortunately not much is known about the current level of digitization and use of 3D content by cultural heritage institutions across Europe.

The final progress report on digitization of cultural heritage resources in Europe by the MINERVA (Ministerial Network for Valorizing Activities in Digitization) project does not consider the category '3D'; as a standard only digitized textual, image, audio and film/video resources are covered in the country reports (MINERVA 2007).

However, there are noticeable exceptions: Greece reported a 10,000 3D objects planned to be digitized by the beginning of 2008 by some of the 84 organizations who responded to a questionnaire survey; France mentioned two pilot projects in the Programme national de numérisation 3D du patrimoine, which focuses on monuments (http://www.map.archi.fr/3D-monuments/); Malta described in more detail Heritage Malta's work on creating 3D models of major sites, e.g., temple sites such as Hagar Qim and Mnajdra, a windmill at Ta'Kola in Gozo, Fort St. Elmo in Valletta and others.

A new project that aims to measure, statistically assess and compare the levels of digitization of materials held by libraries, archives and museums in Europe is NUMERIC (May 2007 - April 2009; http://www.numeric.ws). Their survey instruments also consider 3D digital content and may yield some, though maybe not sufficiently detailed, data on digitization activities in this field.

In the collection of data it should be noted that in the cultural heritage sector 3D content is not produced only by museums; there are also many 3D digitization projects related to built heritage such as monuments, historic buildings or churches, archaeological sites and cultural landscapes. In a conservative estimate, across Europe there have been in the last 10 years some hundreds of such projects carried out or commissioned by public or private owners of built heritage. For a start, it would be useful to create an overview with some basic data on these completed and ongoing projects. One goal of such an overview could be to investigate the possibility of making accessible the 3D content through a common trusted repository, which might be related to the European Digital Library initiative.

Insights on archaeology museums' practices, needs and future aspirations

In a study by the ORION project, some insights in archaeology museums' practices, needs and future aspirations with respect 3D content and technologies have been gained (Hemsley and Spearman 2003). The study, besides meetings, workshops and interviews with experts and practitioners in the field, included a questionnaire survey with responses from 67 archaeology museums of the six partner countries. This sample ranged from very small museums (3000 visitors per year) to large ones with over one million visitors. The study has taken 'archaeology museums' to mean all museums with archaeological collections, estimated to amount to over 5000 in Europe, and embracing a range of institutions from small specialized archaeological museums, e.g.,, the Museum of Cycladic Art in Athens, to large ones such as the Louvre or the British Museum.

The study found that, in late 2002, of the 67 institutions, about 35% had already used 3D objects in some form, though often for only one initial presentation or project. Forty-five percent of the museums had 3D in their

future strategies. 65% thought that 3D has an important or very important role to play in presenting archaeology to the public; indeed, this purpose was understood to have the highest priority. Among the negative factors for 3D, perceived costs reached the same percentage. In addition, lack of appropriate knowledge and fear of technical obsolescence were thought to be critical. Among the positive factors for a broader adoption, a growing number of role models, i.e., other museums that already present 3D digital objects, was thought to be of particular importance.

ORION also produced a roadmap for addressing barriers to adoption through linking the perceived needs and expectations of archaeological museums in 3D applications with priorities in research efforts and technological implementations (ORION 2003). The identified research themes comprise assessment of artefact transit/mobility, 3D scanning, high quality representation, object registration and content management, public access and education, and scientific analysis tools.

Among the priority topics of the roadmap are: delivering high-quality, high-resolution 3D images of objects at affordable costs, automated 3D measurement systems for registration purposes, and high-quality 3D presentations of different restoration alternatives for artefacts and reconstruction alternatives for sites. Furthermore, the roadmap suggests establishing Centres of Excellence for providing expertise in technical, cost and IPR issues.

Cost reduction in 3D digitization

Still an important goal in the field of cultural heritage, declared in the start-up of the 6th Framework Programme, is to reduce by 50% the costs in digitization of cultural and other resources. Such a cost reduction is particularly hard to achieve in the field of tangible cultural heritage such as museum artefacts or sites. In general, digitization policies and strategies aimed at reducing digitization costs in this field must consider that it will be difficult to centralize the first steps in digitization. These will in most cases need to take place on-site, because of either fragility of objects or their immovability. Service units must be formed, personnel trained, and protocols established to achieve similar conditions for data acquisition, equipment moved around, and so forth.

There is a wide range of possible situations for 3D digitization of tangible cultural heritage, e.g., digitization of coins, statues, and historic buildings. Some recent research has been devoted to comparisons of approaches and specific operational aspects in different situations, for instance, it is known that in certain situations, e.g.,, historic buildings with rich ornaments, only combined approaches will provide good results. (cf. Agnello and Lo Brutto 2007; Boehler and Marbs 2004; Patias 2006) The available knowledge on the best approaches in certain situations should be systematically collected, consolidated and made easily accessible.

Furthermore, 3D 'digitization' includes a number of additional and, indeed, very different tasks from what is known from the acquisition of 2D images (e.g.,, 3D modelling). There are a number of guides available that give useful advice on measures that can help reduce the cost of digitization of 2D material, such as the MINERVA-Plus handbook (MINERVA-Plus/Tanner, Simon 2006). Yet, while there is a growing corpus of publications about projects that involved 3D data acquisition, processing, modelling, etc., little knowledge about cost drivers, and how to overcome them, has been made available so far (Niccolucci et al. 2007).

As with most developments in ICTs the potential for cost reduction is almost always offset by the potential for better results (e.g., more accuracy). Hence, in general, the exercise of comparing costs on the digitization using the same requirements is rarely if ever attempted.

The insights and discussion above can be summarized in four **general recommendations**:

- *Leverage the knowledge base in progress, inhibitors and drivers in the digitization of tangible CH in 3D format:* There is a lack of data on the current level of digitization and use of 3D content by cultural heritage institutions across Europe. Particularly important would be to gain a better understanding of the inhibitors and potential drivers in the digitization of physical cultural heritage in 3D format. In order to provide decision makers in the sector with a solid knowledge base, this lack should be addressed by collecting, analysing and disseminating information on planned, ongoing and completed 3D digitization projects, as well as on the factors that hinder institutions from engaging in such projects.
- *Consider 3D digitization work in the fields of built heritage, archaeology and cultural landscapes:* It should be noted that, besides museum projects, there is a need to have a better overview of the many 3D digitization projects related to built heritage (e.g.,, castles and palaces, churches and monasteries, industrial heritage), archaeological sites and cultural landscapes.
- *Consolidate and disseminate the available knowledge in different approaches to 3D data capture:* The field of 3D capture in tangible cultural heritage is characterized by very different situations and a wide range of techniques and operational aspects. Some recent research has been devoted to comparing the results from

different approaches. The available knowledge on the best approaches in certain situations, including their costs, should be consolidated and made easily accessible.

– *Remove the lack of critical procedural knowledge in reducing digitization costs:* Perceived costs are a major inhibitor of a wider participation of museums and sites in the digitization of artefacts and sites. Hence, it is still very worthwhile to pursue the objective of reducing by 50% the costs of 3D digitization. Besides technical improvements this is to a high degree also a matter of procedural methods, control of cost drivers, etc. The critical lack in procedural knowledge should be addressed immediately through gathering and consolidating available expertise and disseminating it widely in the relevant digitization communities. This could be an important function of a European or leading national service centre in 3D digitization.
– *Identify and address barriers to sharing and allowing for re-use of 3D content:* It is also very important to gain a better understanding of potential barriers to bringing together, making accessible and allowin for re-use of 3D content through trusted repositories, which might be related to the European Digital Library initiative.

8.2.2 Promoting a wider adoption of available 3D applications

There are already available useful 3D technologies and a lot of experience in how to use them in effective ways. For example, Virtual Reality systems that make use of 3D models of objects, buildings and landscapes are becoming part of on-site installations in larger museums and visitor centres at sites, or delivered through Websites and more recently, through mobile guides. However, the use of such VR systems is still rather limited due to the high cost of creating interactive 3D environments and the interactive experiences that use them.

The creation of 3D visual content can start from capturing data from existing objects (e.g.,, digital images, photogrammetry or laser scanning) or based on using architectural and other information using Computer Aided Design (CAD) tools. In the following we do not address virtual reconstructions of objects or sites through the use of CAD tools; rather, the focus is on 3D digitization of existing objects and sites.

In this field there have been a number of European collaborative Research and Development projects in cultural heritage 3D content and environments such as: ViHAP3D – Virtual Heritage: High-Quality 3D Acquisition and Presentation; ARCO – Augmented Representation of Cultural Objects; and SCULPTEUR – Semantic and content-based multimedia exploitation for European benefit. In addition, many international and national projects with individual CH institutions have been carried out by research groups with the aim of showcasing the potential of making use of 3D digital content in the CH sector (for example, see the project reports in Ioannides et al. 2006). There is also available more guidance with respect to how to employ available technology in CH heritage projects, for example through the Heritage3D initiative of English Heritage (http://www.heritage3d.org).

This does not mean that 3D technologies are a fully mature field of research and development. Whereas text and image digitization and further treatment is a rather mature technology (with some shortcomings, for example, in the area of OCR for particular fonts), the technology necessary to fully benefit from 3D data is not yet within easy reach of most cultural institutions. There are still many areas in which further progress in research and consolidation of approaches is required, for instance, in the area of 3D digital libraries. Here methods and tools are required for making digital shapes machine understandable and not just human-understandable as today, developing semantic mark-up of content and intelligent agents and ontology infrastructures for 3D content (Bustos et al. 2007).

David Arnold notes that we are – "…in a potentially dangerous situation at present where the tools are immature but there are many potential benefits in the short term of taking up the challenge – " and recommends:

> "During this phase it is very important for cultural heritage professionals to continue the long traditions of curatorship and caution, but their participation in the search for appropriate tools and processes is also essential if the technologies are to evolve to achieve their potential. In the meantime the pioneers in the use of digital artefacts in historic research need to remain aware of the limitations of current technologies and the restrictions on their applicability" (Arnold 2007, 24).

Therefore, it will be beneficial to provide a couple of **recommendations on areas in which progress would be particularly important from the perspective of the CH sector**, and might be achieved in the relatively short term:

– *Reinforce development work in high-quality 3D capture technology at a reasonable price:* With respect to available technologies for 3D data capture there is still a lack of those that are affordable high-quality, standardized and flexible. In order to allow for a wider adoption of these technologies more development work in such should be promoted. Such development work should focus particularly on more intelligent instruments

that incorporate knowledge of, and capability for, different working environments (e.g., to recognise object classes and adapt their modus operandi to handle them optimally).
- *Develop easy-to-use authoring tools for 3D experiences:* Digitizing tangible cultural heritage objects in 3D format is only a first step towards 3D experiences for end-users. The creation of complex 3D environments for end-user interaction will usually require the involvement of specialized companies. But it would be beneficial to provide museum curators, archaeologists and other CH professionals with an easy-to-use toolkit that allows for creating 3D multimedia presentations with limited effort. For example, the authoring tool could support the visualization of a site as it evolved over time, with the possibility of distinguishing between fact, interpretation and hypothesis.
- *Develop solutions for improved re-use and integration of 3D datasets by end-users:* There is a need to better support an easy re-use of 3D objects as well as their use in a variety of contexts. For example, there are still limitations for end-users to handle large file sizes. (cf. the Big Data survey of the UK Archaeological Data Service) In particular, there are shortcomings in the effective integration of 3D datasets from different sources within the context of analysis, interpretation and presentation. For example, desktop GIS should allow for making datasets more easily available in an integrated fashion for researchers and practitioners. In this context, it will be beneficial to support better the extraction of areas of potential interest from large data-sets.
- *Provide solutions for effective rights management of complex 3D content:* 3D content will often integrate a number of media objects and, hence, be more difficult to manage than other content, such as individual images. With respect to such content CH institutions will worry about the capability for a proper handling of provenance data and IPR in the digital content. Therefore, effective solutions for the management of provenance data and rights clearing and licensing are of particular importance for achieving a wider use of 3D objects and environments.
- *Promote adherence to the principles of the London Charter for the Use of 3D Visualization in the Research and Communication of Cultural Heritage:* There is an increased awareness of the importance of ensuring both that 3D visualization methods are applied with scholarly rigour, and that the visualizations accurately convey to users distinctions between evidence and hypothesis, and between different levels of probability (e.g.,, in the 3D reconstruction of heritage sites). This has been addressed in the London Charter (http://www.londoncharter.org) which aims at establishing internationally-recognized principles for the use of 3D visualization by researchers, educators and cultural heritage organizations. The methodological and other principles for integrity, transparency, quality as well as community in 3D visualization should be adopted and consistently used by subject communities and other stakeholders in the CH sector.

8.2.3 3D multi-user Virtual Reality environments

Interactive Virtual Reality (VR) environments are of high interest to the CH sector as they allow for expanding access to cultural assets and synergies with other domains such as education and entertainment. VR particularly will be considered for purposes that would be difficult or impossible to achieve by other means, for example,
- to present collections that cannot be exhibited in a traditional way because of lack of space or fragility of artefacts;
- to bring together, and maybe 'repatriate', in the virtual space precious objects from different collections that are distributed around the world and could not easily be combined in a physical exhibition due to high cost of transport, insurances, etc;
- to provide virtual access to cultural heritage that is located in remote, difficult to reach and protected areas;
- to present virtual reconstructions of objects or places that have been partially destroyed or entirely lost.

Within the wide spectrum of possible approaches and available applications for VR, here we mainly address Web based multi-user 3D VR environments. This selection is based on the considerations that
- 3D VR will usually be the most adequate form of presenting and communicating tangible cultural heritage;
- Web-based solutions allow for reaching a wider, indeed, global audience, and
- most end-users will not only be interested in exploring 3D digital objects but also, or even more so, in having the opportunity to communicate with other visitors.

The latter point is exemplified by the huge success of multi-user 3D VR environments. There are several such environments, e.g.,, Active Worlds, Entropia, Second Life and There. These environments typically offer more opportunities for their users to create own spaces and objects as well as forms of social interaction than massively

multi-player online games such as Everquest, Doom or World of Warcraft, partly due to constraints of settings and rules of such games.

The paradigmatic example of a multi-user 3D VR environment at present certainly is Linden Labs' Second Life. According to Second Life statistics, on January 23, 2008 it had 12,107,576 residents, of whom 622,410 had logged in during the last 14 days. A 'resident' is defined as a uniquely named avatar with the right to log in, trade Linden Dollars and visit the community pages. According to Philip Rosedale, CEO of Linden Labs, virtual residents transact more than $1 million a day and about 40,000 residents are cash flow positive from selling various virtual objects (Farber 2007). Almost all social, commercial, and entertainment interaction spaces and content in the Second Life environment have been created by the residents themselves.

Interestingly, there are also about 150 galleries, museums, sculpture parks and historic environments of varying purpose, setting, scale, collection types, media richness, visitor engagement and social interaction, and there are lectures, tours, audio guides, docents, and even museum shops (cf. the detailed analysis by Urban, Marty and Twidale 2007; on some existing technical limitations see Wieneke 2007).

Museums, heritage sites and arts and humanities institutes have, since the 1990s, explored emerging multi-user 3D environments to create new forms of exhibitions and collaborative user experience. There were projects with proprietary environments (e.g., from Blaxxun or ActiveWorlds), though, most have favoured custom-built environments under their control. Many of these virtual environments were developed with cultural heritage education as the prime focus. Recent examples are the Shrine Educational Experience (SEE) project (Di Blas, Hazan and Paolini 2003) or Discover Babylon, which in its final form should become an educational multi-player game in 3D recreations of temples and places of the first Mesopotamian city-states (Lucey-Roper 2006).

It seems timely to bring together and evaluate the lessons learned so far with multi-user 3D VR environments created by CH organizations on their own as well as within environments such as Second Life.

Particularly interesting points in such an evaluation would include:

- critical success factors for the sustainability of the investment, e.g.,, total cost of ownership, funding models, cooperations and partnerships, technical frameworks, media richness, marketing, etc.;
- capability to attract and retain users with object presentation centric vs. user interaction centric designs;
- effectiveness of different educational paradigms, e.g.,, guided, instructional, moderated, vs. open, explorative, constructivist approaches.

Moreover, as users of future cultural heritage 3D multi-user VR environments will compare them with commercial environments a good understanding of where the industry players (e.g., in the area of games and e-commerce) are heading is important for successful ventures in this field by CH organizations.

A general **recommendation** for intended projects in the field is **firstly to acquire a good understanding of the success criteria of sustainable 3D multi-user VR environments**:

Cultural heritage organizations have already, often within the framework of R&D projects, explored 3D multi-user VR environments as an opportunity to offer new forms of educational experience. Considering the current wave of commercial 3D environments such as Second Life, an evaluation should be made of these CH projects. Further CH investments in 3D multi-user VR environments will require a good understanding of the critical success factors for achieving sustainable results.

8.3 Mobile, location-based cultural heritage services

A large part, if not most, of tangible cultural heritage is experienced through visiting historic towns, monuments such as castles, churches or monasteries, and archaeological sites. Furthermore, many regions have invested in cultural trails or routes to allow visitors to learn about interesting sites and local culture. Therefore mobile services are an interesting opportunity for regions, towns and individual sites to offer location-based cultural and other information. There are already many general purpose mobile information solutions available on the market and the major market players strive to roll out ever more sophisticated, added-value, location-based and navigation services.

According to recent market research, the worldwide market for location-based telecommunication services is expected to reach nearly 1.5 billion dollars in 2007. Prices for GPS-enabled devices are expected to keep falling and, indeed, ever more portable devices are shipped with GPS, including cell phones, PDAs, notebooks, digital cameras, personal navigation devices and portable media players (Infoshop 2007, Insight Research 2007).

An increasing number of cellular and other wireless carriers provide location-based services (e.g.,, 'Yellow Pages', guidance information, local search, etc.) which are adopted by the consumers along with other IP-enabled services such as instant messaging, content sharing and other social communication facilities. The main private use of navigation devices is still vehicle navigation, where users see a clear benefit in getting voice-guided driving directions, traffic alerts and alternative routes, and even the location of gas stations with the lowest prices, e.g.,, Sprint in the USA (Pike & Fischer 2007).

Of interest to cultural heritage organizations may be special services for touring and excursions, such as the recently launched Tele Atlas Touring Series and MAD MAPS (USA), which feature routes for scenic road trips with turn-by-turn directions and information on points-of-interest such as local roadhouses, roadside attractions and recreational areas (Teleatlas.com 2007a*)*.

In September 2007 Tele Atlas also announced that during 2008 it will expand the availability of 3D landmarks of major U.S. and Canadian cities for use in navigation devices and location-based applications to 1,400. The company at the same time announced the availability of their Digital Elevation Model for North America, which followed the launch in August 2007 of such a model for Europe (Teleatlas.com 2007b). In August 2007 NAVTEQ announced worldwide availability of Digital Terrain Model and Satellite Imagery to enable more realistic map display in location-based and navigation applications.

Due to an increasing number of value-added services, the automotive navigation systems market is expected to see a further robust growth from an already high level of usage. In contrast, the use of navigation services with handheld mobile devices for leisure purposes (e.g.,, outdoor recreation) will only in the coming years demonstrate higher growth rates (Reportlinker.com 2007).

According to a report by Berg Insight (2007) on the development of online maps and turn-by-turn navigation services for mobile handsets in Europe, the number of mobile subscribers using such services is expected to grow from 4 million users in 2007 at a compound annual growth rate of 60.8% to reach 43 million users in 2012. Revenue from subscriptions and advertisements is expected to reach € 512 million by 2012 up from € 96 million in 2007 – a compound annual growth rate of 39.8%.

However, the report 'Location-Based Services: Where Are You?' (Jupiter Research 2007) warns against too high expectations put into navigation-focused services for handsets. In their survey, less than 3% of cell phone users reported routine use of maps or turn-by-turn directions in their travels. In contrast, 26% of cell phone users between the ages of 18 and 24 wanted mobile social networking applications based on their friends' locations, and 42% of parents with children under the age of 13 were especially interested in and willing to pay for services that allow them to track their child's location.

Indeed, besides vehicle navigation the most interesting services for businesses and private users are in the field of locating and tracking people and goods for purposes of logistics, security, and communication in cases of uncertainty. There is much value in peace of mind, for example, through a service such as 'Trace a Mobile' which is offered in the UK by Orange, T-Mobile and Vodafone, as is in services that support people in keeping in contact with their social network (e.g.,, through mobile social networking services).

What can be learned from this for the development of location-based services for cultural routes or smart environments at larger CH sites is that socially aware applications are likely to be more successful with users than presentation-centric applications. Visitors to CH sites are often families and groups of friends who not only want to experience and learn something about the site, but as much want to relate to each other through communicating ideas that they have about the site, objects on view and the information that is given about them.

Furthermore, people may not necessarily want to receive a continuous stream of information about their environment, but would like immediate access to information about objects that have captured their interest. One of the most advanced markets for such solutions is Japan. Quick Response, a 2D barcode that can be put on business cards, magazine pages, packaged goods, etc., has been a tremendous success, and QR code readers now come preinstalled on almost all new 3G cellphones. Another example is Mapion, a mobile local search service launched in early 2006 by CyberMap Japan and GeoVector. It allows users to identify available content from CyberMap's point of interest databases by just pointing the mobile at shops, restaurants, historical sites, etc. In June 2007 the service was reported by GeoVector to have over 700,000 page views per day (Inbabble.com 2007).

A **general recommendation** for intended projects in the field is **to examine carefully all available opportunities for providing mobile, location-based cultural heritage services**:

Mobile location-based services provide interesting opportunities for the heritage sector to offer information services for cultural trails and routes as well as individual monuments or sites. Most often such services will be

implemented on existing commercial networks and initiatives to offer more than general purpose information. An analysis of experiences that have been gained from co-operations in such initiatives across Europe would be helpful to inform and guide newcomers to this field.

At the same time, applied research in this field should keep an eye on the advanced solutions that are already available on the market or in preparation by the major commercial players. They roll out ever more sophisticated 'added-value' location-based and navigation services, hence, R&D topics must be carefully chosen so as not to 're-invent the wheel'. In particular, such topics will be related to the aspect of context-awareness in mobile information services (e.g., socially aware applications) which requires much more modelling of the context of use and technical capability to support novel concepts of interaction with CH information sources, including, for example, mobile 3D content or historic avatars.

8.4 'Social software' applications and user-created content

There is a massive and growing use worldwide of 'social software' applications such as Weblogs, Wikis (e.g., Wikipedia), bookmark and content sharing platforms (e.g., del.icio.us, Flickr, YouTube), and social networking services (e.g., Facebook, MySpace).

The growth in Weblogging may provide a good example for illustration: In April 2007, the so-called "blogosphere", which is tracked by Technorati on a regular basis, amounted to over 70 million individual Weblogs, 120 times more than in 2003; growth from 35 to 75 million blogs took less than one year (320 days). On average about 120,000 new Weblogs are being created worldwide each day (about 1.4 blogs every second of every day), and there are about 1.5 million postings per day. Furthermore, tagging, the practice of assigning a category or descriptor to blogs is adopted more widely. About 35% of all posts that Technorati tracks use tags, and the number of bloggers that are using tags is increasing month over month (Sifry 2007).

According to a Pew Internet report based on a telephone survey of a representative sample of bloggers in the US, 8% of Internet users already keep a blog while 39% read blogs. More than half of the bloggers (54%) are under the age of 30, and the bloggers are evenly divided between men and women. Most bloggers are primarily interested in creative, personal expression, documenting individual experiences, sharing practical knowledge or keeping in touch with friends and peers. About 54% say that they have never published texts anywhere else. Fifty-two per cent blog to express themselves creatively, 57% include links to original sources and 56% spend time trying to verify facts they want to include in a post (Pew Internet & American Life Project – Lennart and Fox 2006). Similar findings are reported by the German study 'Wie ich blogge?!' ([How I blog?!)] with 5,246 participants (Schmidt and Wilbers 2006).

Growth figures similar to the ones in Weblogging are reported for major content sharing platforms and social networking services. For example, between September 2006 and September 2007 the number of visitors to the image sharing platform Flickr grew by 90% to 13.15 million, and the number of visitors to Facebook grew by 129% to 30.6 million (Schonfeld 2007).

The huge success of social software tools and services more than anything else has to do with people's thirst for self-expression, taking part, and sharing of ideas. Furthermore, digital cameras have made it easy to document and present on content-sharing platforms leisure, travel and other experiences.

The term 'user created content' does not fully capture the meaning of the phenomenon as the content could just as well remain hidden away. The phenomenon is better understood by the social functions of the tools the people use to openly publish, interlink, annotate, comment on and re-use the content. The attribute 'social' in social software stems from the fact that such tools and services in particular promote connections, exchanges and collaboration among people who share common goals and interests. It is also acknowledged that they foster bottom-up development of communities of interest and practice, whereas typical institutional IT systems represent a top-down approach with centralized information access, authoritative information, defined user roles and permits.

The social software applications addressed above usually are subsumed under the label Web 2.0, which comprises many other Web-based applications that allow for creating, syndicating, and re-using content as well as services (cf. O'Reilly 2005; Hinchcliffe 2006).

The tremendous growth in the use of Web-based social software and other Web 2.0 applications has so far seen very little spill-over into the cultural heritage sector. It is understood that social software could have a strong impact in terms of involvement in online museum exhibitions and virtual communities that may form around certain cultural heritage topics, artefacts and sites. Yet, social software is about the Web as an environment of participation (many-to-many) rather than a mere source of information (one-to-many). The applications put

users and user-generated content and not the institution and its authoritatively curated content at the centre of the equation.

This represents a great challenge for many institutions and their current practices of interpreting and communicating cultural heritage. Attempts at involving on the Web communities of interest and allowing for non-expert contextualization and interpretation typically show a low level of 'opening up'. An illustrative example is the "Moving here" project of the UK Public Records Office together with many libraries and museums which has created a huge online resource on different immigration communities (www.movinghere.org.uk; Geser and Wood 2004). Here a template for uploading text and own images (or attaching material from the project database) is offered and the content is checked for possibly offensive statements or visuals.

'Social software' tools allow for more open approaches, but, as discussed in a recent Museums on the Web conference paper, the challenges implied in this are profound. For example, museums will ask: "What about dumbing down? Who is going to moderate? What if they don't like our exhibition? Surely our curators are the experts, not some random bloke who rode one of those bikes when he was a kid…?" Furthermore, there are issues of ownership of content, deep-seated concerns about authority, issues of security and reliability of external services, and fears about the public and sponsor perceptions of the institution (Ellis and Kelly 2007; cf. Ridge 2007).

The authors are convinced that "the opportunities which Web 2.0 presents are incredibly exciting, particularly given the content museums have and the audiences we seek to engage", and that "doing Web 2.0 […] because our users expect it, because it adds real value to what we – and they - have to say, or because it extends the content experience in real and meaningful ways, is, of course, right". They suggests some strategies for overcoming the barriers that make museums shy away from using Web 2.0 applications, and admit that "it is only by working with these technologies 'in the wild' that we begin to understand exactly what the benefits and risks of these approaches are".

However, there are also other options for cultural heritage institutions to become acquainted with social software or Web 2.0 applications. First, by using applications themselves in the context of reseach work, online exhibitions or learning programmes. For example, a curator uses a Weblog that allows for user comments or an archaeological study team uses a Wiki. Secondly, through a "walled garden" approach, for example, in a project with schoolclasses or Arts and Humanities students in a restricted group on a content-sharing platform such as Flickr. Thirdly, based on the experiences acquired, open up to wider communities of interest, but have a certain level barrier to entry to discourage spam while encouraging people who genuinely want to take part and are serious about the ideas and content they provide.

A **general recommendation** for intended projects in this field is **to investigate and examine carefully appropriate approaches to user-created content**:

Cultural heritage institutions should be aware of people's increasing interest in expressing themselves, taking part, and sharing ideas and own content (e.g., from digital cameras), which is driving the tremendous growth in the use of social software (e.g., Web logging, content-sharing platforms, etc.) and other Web 2.0 applications. Making use of such applications can allow for involving users in online exhibitions and virtual communities that may form around certain cultural heritage topics, artefacts and sites.

However, such applications put users and user-generated content and not the institution and its authoritatively curated content at the centre of the equation. The challenges implied in this are profound and will raise issues of ownership of content, liability, loss of authority, public and other stakeholder perceptions of the institution, etc. Coming to terms with these issues will require research on, and careful experimentation with, appropriate approaches that work for CH institutions.

9 The European Digital Library and the physical cultural heritage of Europe

In April 2005, an initiative was started by the heads of state and of government of France, Germany, Italy, Hungary, Poland and Spain for building a virtual library of European dimension comprising cultural and scientific heritage content. The initiative was in part a reaction to Google's digital library project, which had the announced aim of digitizing and making accessible online 15 million books. Consequently, the initiative for a European Digital Library (EDL) was quickly followed by the commitments of 19 national libraries of EU member states.

The initiative was welcomed by the European Commission, which considered it as a flagship project under the i2010 European Information Society policy framework, which was adopted on 1 June 2005. From September 2005 to January 2006 a major online consultation on the EDL was conducted to inform the Commission about the opinions of stakeholders across Europe. A press release in March 2006 informed about the steps already taken and those planned for the EDL, the rollout of which was described as follows:

> "By the end of 2006, the European Digital Library should encompass full collaboration among the national libraries in the EU. In the years thereafter, this collaboration is to be expanded to archives and museums. Two million books, films, photographs, manuscripts, and other cultural works will be accessible through the European Digital Library by 2008. This figure will grow to at least six million by 2010, but is expected to be much higher as, by then, potentially every library, archive and museum in Europe will be able to link its digital content to the European Digital Library." (Europa.eu 2006)

9.1 From the Lund Principles to the European Digital Library initiative

In April 2005 the aim of making Europe's heritage available online was not a new topic, because at that time much work was already being carried out by the EU member states based on the Lund Principles and Lund Action Plan. Issued in 2001, these documents established an agenda for actions to be carried out by member states and the European Commission. These actions aimed at promoting a higher level of digitization and online availability of cultural content and included mechanisms for coordination and cooperation among the member states, national inventories, centres of competence, and good practice guidelines. In particular, the National Representatives Group (NRG) of European Ministries of Culture was established and from March 2002 onwards received operational support from the MINERVA – Ministerial Network for Valorising Activities in digitization project, funded under the FP5-IST programme as a thematic network with €1.4 million for a period of three years.

While in a relatively short time much progress was achieved in making guidance material and reports on digitization activities of the member states available, around 2004/2005 the initiative was felt to have lost its momentum. One renowned expert, who has been involved in the initiative from the very start of the Lund Principles and Action Plan, in September 2004 noted that, "Progress towards widespread adoption and take-up of the principles…has, it is fair to report, been patchy", and warned that a number of key issues such as collaboration, metadata creation, and long term access to the digital assets needed sustained efforts (cf. Ross 2004).

Also, the update in November 2005 of the Lund Action Plan through the so called Dynamic Action Plan (DAP) for the EU coordination of digitization of cultural and scientific content mentions that "many of the barriers identified within Lund continue to exist" and suggests a broad spectrum of actions in the areas of users and content, technologies for digitization, sustainability of content, digital preservation, and monitoring progress (DAP 2005).

Hence, the European Digital Library initiative came at the right time for the European Commission to give new impetus to digitization work on cultural heritage underway in the member states and to contribute at the European level by adjusting the required instruments. In particular, this includes:

- the definition of the EDL as the flagship project of 'i2010: Digital Libraries' initiative (EC 2005c);
- the Commission's Communication on 'Digitization and online accessibility of cultural material and digital preservation' of 24 August 2006 (EC 2006e; see also the Commission's impact assessment document EC 2006f);
- funding for digital content and metadata enrichment projects under the eContent Plus programme (2005–2008);

– funding of related R&D projects under the 6th Framework Programme (in the relevant last call for proposals) and the 7th Framework Programme, Challenge 4: Digital Libraries and Content;
– furthermore a High Level Expert Group on Digital Libraries was established that advises the Commission on organizational, legal and technical challenges issues – IPR (e.g., orphan and out-of-print works) and access to results of publicly funded research, for instance.

The intended integrative effect of the 'i2010: Digital Libraries' initiative is excellently presented in a brochure of the European Commission's DG Information Society and Media (EC 2006c) which describes the fields of policy actions and 24 relevant projects under the eContentPlus, eTEN, FP5 and FP6 programmes.

Among the projects are (full titles and URLs are provided in the *Bibliography*):
– those in support of the European national libraries' effort to create a common infrastructure for making available their digitized collections (TEL, TELplus and TEL-ME-MORE, and the related EDLproject);
– more general digital library and repository infrastructure projects (BELIEF, DELOS, DRIVER, DILIGENT);
– some that deal with specific content like audio and audio-visual content and related material such as Braille music sheets (CONTRAPUNCTUS, EASAIER, MEMORIES, PRESTOSPACE);
– projects with a focus on multi-lingual access (MACS, MICHAEL, MultiMATCH);
– projects that aim at ensuring the long-term preservation of digital assets (CASPAR, DPE, PLANETS).

Strikingly, the only projects mentioned that deal specifically with tangible cultural heritage such as monuments and archaeological sites are the TNT – The Neanderthal Tools (FP6-IST), and, to a limited degree, BRICKS – Building Resources for Integrated Cultural Knowledge Services (FP6-IST). EPOCH was not included in the list of relevant projects although a major focus of the network has been to build a common infrastructure or 'pipeline' for processing digital cultural heritage from data acquisition to presentation and communication.

9.2 Critical neglect of digital content of physical cultural heritage

In recent years there has been considerable progress with respect to (mass) digitization of cultural heritage holdings on the national level, particularly regarding collections of libraries and archives. On the European level, the work since 2002 of the National Representatives Group of the European Ministries of Culture and the supportive thematic network projects MINERVA, MINERVA-Plus and (current) MINERVA eC on promoting the digitization of cultural and scientific cultural heritage must be acknowledged. Since 2005 the European Digital Library initiative has given further momentum and placed the aim of making more digital heritage resources accessible online high on the cultural heritage policy agenda of national and regional authorities.

However, still the European Digital Library initiative is mainly driven by the larger national institutions, in particular, the national libraries that receive a large part of the available funding and can afford a digitization department. Consequently, the European Digital Library initiative will for some time to come mainly build on their digitized resources such as books, manuscripts, and photographs.

Indeed, digitizing the manuscripts, incunabula, old printed books, and other historical printed documents held by the national libraries will guarantee a substantial coverage of Europe's textual heritage. For example, the consortium members of the eContentPlus targeted project ENRICH, national libraries and some other institutions, together hold almost 85% of currently digitized manuscripts and aim to make accessible more than five million digitized pages.

The situation is very different with respect to the artefacts held by the thousands of museums across Europe. Most of these artefacts are unique for being individual pieces and for the context from which they come. Moreover there is Europe's tangible heritage of monuments, churches, monasteries, castles, historic towns, archaeological sites and so forth, which also deserve to have a presence in digital libraries for purposes of arts and humanities studies, appreciation by cultural tourists, and cultural resources management.

However, digital representations of the extremely rich but dispersed physical cultural heritage often are neglected in efforts to create large-scale libraries. To provide a few illustrative examples: in a speech at the National Library of France on 7 December 2006, Horst Forster (Director Content, DG Information Society and Media of the European Commission) emphasized that the approach taken in the development of the European Digital Library will guarantee that the digital objects made accessible will:

> "…consist not only of objects from national libraries but from all kinds of cultural organizations at all geographic levels. After all Europe's heritage is not confined to a few privileged large organizations but has

> been collected over the centuries in many regional and local archives, libraries and museums in all member states, covering all types of content: text and books, sound, manuscripts, scientific and cultural artefacts, moving and still images and multimedia art." (Forster 2006, 4)

A more recent example is the EDLnet (European Digital Library Network) that is funded under the eContentplus programme and aims at "Creating Cross-Domain Consensus for the European Digital Library". The project sees "a four way street" to such a library that comprises digital collections of libraries, museums, public archives and audio-visual archives (cf. EDLnet website, Moree 2007).

As noted in section 8.2 there is also a lack in effort to acquire knowledge about the current level of digitization and use of 3D content by cultural heritage institutions across Europe, which comprise museums that hold collections of physical heritage, monuments such as castles and palaces, churches and monasteries, archaeological sites, industrial heritage and so forth.

However, it is clear that part of the neglect of 3D content of physical cultural heritage is due to the difficult question of how a 'critical mass' of such content for the European Digital Library could be realized. In the 6th Framework Programme the ambitious goal was set for innovative R&D to help reduce by 50% the digitization costs for cultural heritage and other resources. Considerable cost reduction can be achieved through automation (e.g., book scanners), which, however, will not be easily achieved in the field of museum artefacts and built heritage.

A centralization of the first steps in digitization will not work as in most cases the digitization needs to take place on-site, because of either the fragility of objects or their immovability. Hence, service units must be formed, personnel trained, protocols established to achieve similar conditions for data acquisition, equipment moved around, and so forth. Furthermore, it must be noted that 3D 'digitization' includes a number of additional and, indeed, very different tasks from what has been learnt from the acquisition of 2D images.

High costs but limited resources are likely to lead to an approach that reinforces current consumption patterns of physical cultural heritage. To provide but one example, in Italy, according to official statistics from SISTAN the five 'top-sellers' are the Coliseum complex in Rome, the Pompeii site, the Uffizi Gallery and Accademia Gallery in Florence, and the museum of Castel S. Angelo in Rome. They have 50% of the visitors of the 463 state-owned museums, with the Coliseum reaching alone 20%. Do we want to reinforce this pattern on a European Digital Library by turning it into a marketing engine for the already over-visited museums and sites; or should we develop and present its content in a way that ensures a balanced coverage of Europe's cultural riches and, potentially, impact to some degree on consumption patterns?

Furthermore, Europe's landscape of about 20,000 museums and many more visitor centres and sites in the EU-27 is characterized by patterns of ownership and management that require well balanced digitization policies and support measures. While there is a lack of accurate comparative data for all member and applicant states, based on a compilation of data provided by the independent museum association Nemo (http://www.ne-mo.org) it can be said that in many countries the state or federal public agencies own and manage only 10–15% of the museums. A large part, usually over 50%, is owned and funded by local government, and a significant part is owned by private individuals or other organizations, such as churches and charities.

Will EU-level and national digitization and digital library policies and guidelines targeted at acquiring museum content, especially also from the European regions, impact on all them? This is rather unlikely. The fragmented situation of ownership and the fact that smaller and medium-sized regional institutions respond to priorities other than the ones that are managed directly or indirectly by member state administrations must be taken into account. "Ignoring this fragmented situation would undermine any EU strategy on digitization: small and medium memory institutions are the SMEs of culture, and must receive the same attention SMEs receive in economic policies." (Niccolucci 2007, 9) Hence there is a need for support in the development of strategies and concepts that work in favour of Europe's rich but dispersed heritage, based on considerations of related policy domains (e.g., tourism and regional development), and studies on the potential socio-economic impact of digital libraries of tangible heritage.

9.3 Towards interoperable 3D content for the EDL

In section 8.2 a number of recommendations on measures are made that could help stimulate the creation of a larger volume of 3D content of physical cultural heritage. These comprise, but are not limited to, measures that
- leverage the knowledge about inhibitors and potential drivers of 3D digitization by cultural heritage institutions;
- make affordable high-quality, standardized and flexible technologies for 3D data capture;
- disseminate critical procedural knowledge in reducing digitization costs;
- address barriers to bringing together and making accessible 3D content through trusted repositories,
- provide solutions for effective rights management of complex 3D content.

The sections on 3D data capture, modelling, documentation, visualization and presentation in chapter 6 highlight the many aspects of 3D digitization, especially issues in viable mass digitization that are currently unsolved research problems. Rich repositories of interoperable 3D content of the wide range of physical cultural heritage will be a viable proposition only if the required set of digitization tools becomes available.

3D objects require content classification of non-textual documents (similar to images or AV material but with some important further requirements); search and retrieval would benefit from augmenting or replacing descriptive (textual) metadata using similarity algorithms. Furthermore, linking in 3D documents and navigation through distributed 3D documents must be considered. Many of the issues also appear with images and depending upon the operations undertaken image data may be even more demanding than 3D. For example, the search for similar objects in a digital library may be more simply handled by searching for similar shapes in 3D than seeking to recognise similar 3D objects in images of them. Indeed, the requirements for creating an effective library of 3D content are considerable and there are still many challenges for research and technological development (Bustos et al. 2007; Havemann et al. 2006).

More specifically, much of EPOCH's work concentrates on leveraging the use of 3D computer graphics in the presentation and interpretation of monuments, archaeological sites and museums collections. This interpretation requires a variety of tools for the creation and management of 3D applications such as easy-to-use authoring tools for creating 3D multimedia presentations, exhibitions and other interactive user environments. In this context the different emphasis in the goals of digital libraries and virtual museums should be noted. Digital libraries typically focus on content delivery, whereas the aim of virtual museums is to present, communicate and, thereby, interpret cultural heritage. A useful formula may be 'Virtual Museum = Digital Library + Communication', which emphasises the mission of museums to communicate and interpret rather than mainly provide access to digital documents.

The content delivery paradigm of libraries also is present in The European Library (TEL), which has been developed based on considerable effort by the national libraries and community funding and forms a major basis for the European Digital Library. Hence, there is the question of whether museums will have to accommodate to this paradigm or if there will be environments and tools in the EDL for heritage communication beyond search and retrieval and display of content from cultural heritage institutions across Europe.

However, in building the European Digital Library, which is conceived as a multilingual common access point to the distributed content (i.e., held in different places by different organizations) in the first place the issue of cross-domain interoperability will need to be addressed. For example, there is a legacy of different metadata standards and other factors that make information integration a particularly difficult task; to support advanced search and exploration often enhancement of underlying legacy metadata will be required (see sections 7.2 and 7.3).

The EDLnet project has, among several objectives, been entrusted to find consensual technical solutions to interoperability issues for the future EDL. EDLnet, started in July 2007, is a thematic partnership funded under the eContentplus programme for a period of two years. Recent presentations describe in detail a roadmap of short term (2008) and long term (2010 and beyond) technical and semantic interoperability issues. (Gradmann 2007a and 2007b)

Regarding metadata for search and retrieval domain-specific Dublin Core Application Profiles are considered that take into account the descriptive metadata standards of the different cultural heritage domains. Instead of a higher-level interoperability application profile, semantic interoperability techniques should be employed to implement semantic mappings and the cross-searching of descriptive metadata. Use of SKOS and OWL is suggested for making controlled vocabularies machine understandable to create a data layer ready for semantic

query methods. The value added through semantic interoperability functions is understood to be one of the unique selling points of the EDL.

With respect to models of digital information objects in the short-term only complete objects such as ‘books’ or ‘artefacts’ are targeted (in the latter case, e.g., a scanned museum artefact). For the longer term the level of granularity should be refined to allow for dealing with intra-object reference structures. For complex, multimedia objects, which may also contain 3D content, description and packaging standards such as METS, Fedora or MPEG 21 (DIDL) are considered.

10 CH ICT maturity life-cycle, different perspectives of stakeholders, and models for technology transfer

In the creation and communication of a research agenda for cultural heritage ICT applications it is important to recognise that different stakeholders have different perspectives on the perceived maturity of individual technologies. These perceptions have a fundamental impact on the different communities' perception of the usefulness of pursuing a research topic and hence on the priorities embodied in the agenda.

For these reasons a model of the maturity life-cycle of technologies has been developed to serve as a tool for collecting the views and assessments of the different stakeholders and, in order to provide a consolidated shared framework, to make explicit the different perspectives.

The following sections present the technology maturity model, discuss gaps in the development from basic and applied R&D to mature CH technologies, and describe the differing interests and perspectives of researchers, product developers, vendors and service providers, cultural heritage institutions, and CH support centres in CH ICT applications.

10.1 Technology maturity life-cycle model

The model of technology maturity used in the research agenda definition activity builds on the standard model of the diffusion of innovations (Rogers 1962, 1995), but includes phases that are often not considered in the application of the process model. In the Figure below these phases of R&D, in which new technological methods and prototypes are created, and early phases of product development are included.

In the standard model, the technology diffusion process starts once a functioning and tested (prototype) application becomes available and is adopted by one or more innovative companies in search of a competitive edge. Then, industry solutions appear which usually target larger organizations, and find some early adopters, based on a more stable and scalable solution. Next, competing industry solutions appear which may also target smaller organizations, and are adopted by a much broader group of organizations, the so-called 'early majority'. Then, the mature and well-serviced technical solution will find a large, perhaps industry-wide, 'late majority'. Finally, even the most confirmed sceptics will decide to use it.

This model has been questioned and improved by Geoffrey Moore specifically with respect to 'high-tech products' (Moore 1991). Moore identified a 'chasm' between on the one hand the first users (innovators and early adopters) of such products, which may still to some degree be immature, and, on the other hand, later customers who will only adopt a mature product.

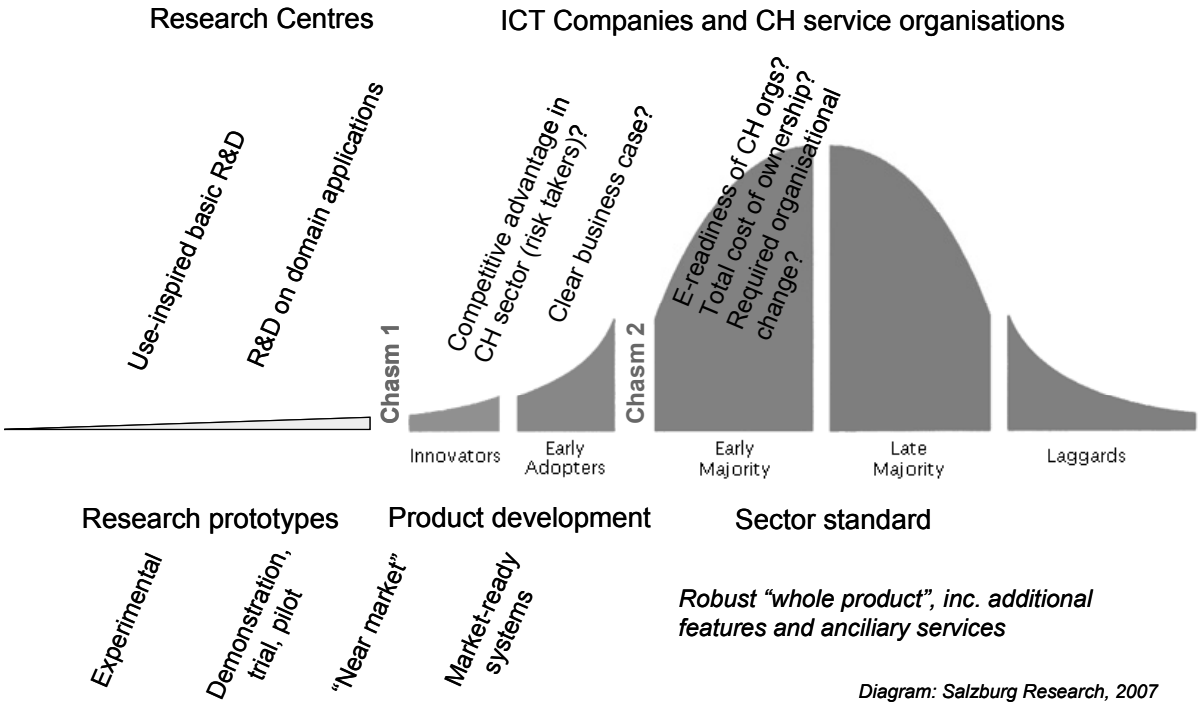


Figure 10.1: Phases and chasms in the technology maturity life-cycle model

In the diagram, this is 'chasm 2', because we observe that there is another, earlier, chasm regarding the transfer of a research prototype into the product development phase. The research prototype has proceeded from an experimental and demonstrator solution to a 'near market' solution, but a 'market ready' would require much further development.

Hence, we identify two chasms in the diffusion of research results:

- *Chasm 1*: This chasm concerns the transfer of 'near market' ICT prototypes to innovators and other early adopters in the CH sector. This transfer is hampered by the following situation: 1) there are only few research-driven companies that develop results of applied research into robust working solutions for the target market CH, and 2) this market is not characterized by strong incentives for seeking a competitive advantage as well as capability for the risk-taking that is required when adopting novel applications that have not so far proven their benefits. 3) For academic computer scientists the research issue is typically regarded as solved once the 'near market' prototype has been produced and results published. Little career advantage is perceived in further investment of time.
- *Chasm 2*: This chasm concerns the adoption at a late stage by many institutions in the CH sector of a more mature application, a whole product with additional features and ancillary services. The main problem here is that most CH sector institutions are small organizations that lack technical staff and support and are not able to cover the total cost of ownership for ICT applications from their operational budget. Many of them would be happy enough if they could afford a state-of-the-art website, have in place a better collection management system or could enhance exhibitions with interactive displays.

Often 'chasm 1' is overcome by certain types of technology company in close collaboration with innovators of a niche market that has specific needs. Such companies are to some degree engaged in R&D, for example, in cooperative research projects that are co-financed under national or European funding programmes. They form an interface through which results are transferred from applied R&D to innovation-oriented organizations. However, for a number of reasons such an interface has not so far evolved to a sufficient degree in the field of cultural heritage ICT.

In section 10.4 below different business models are suggested that could allow for a more effective transfer of R&D results as well as a wider deployment of new ICT applications in the CH sector. The following sections first address the different perspectives on research topics and technology development in fields such as cultural

heritage ICT applications that are characterised by many stakeholders and multi/inter-disciplinary research and development.

10.2 Issues in decision-making and stakeholder support

The 'Two Chasms' model highlights the difficulty of building 'end user' perspectives directly into a research agenda – you need users with long-term perspectives, lots of altruistic patience and a very broad understanding of the research process.

In the EPOCH Research Agenda activity discussions have started from the basis of asking 'users', as represented by cultural heritage professionals via their user requirements, for perceptions of the priorities that they would place on particular developments. However, the lack of technological awareness in such groups can mean that their conceptualization of what might be considered a research issue represents real challenges, but challenges that a computing researcher would regard as operational. At the same time, the technologist's view of a real research topic is perceived by the cultural heritage practitioner as verging on science fiction. From their own perspectives both views may well be right.

Thus, some "blue-skies" research may be undertaken (for example the investigation of some interesting properties of a new material). After a potentially substantial period of research the issues may become more engineering orientated (for example "can the material be manufactured in sufficient quantities, economically?" or "what is its environmental impact?"). As these issues are resolved successfully, the material may become usable in the redesign of particular equipment, with commercial interests bringing the new material to market in innovative and attractive products. Only at this stage will the original blue-skies research be turning into applications with economic return for the original research.

This research cycle may have taken a significant time during which the will to pursue the original line of research needs to be maintained if the initial promise is to be realized. Of course, in many cases initial promise will not be realized because it may be found that the initial concept failed to take into account some important factor and the research demonstrates that this factor is so intractable as to negate the potential benefits of the line of enquiry. Maintaining a decision to invest in particular lines of research is an issue of judgement, based on perceived benefits relative to perceived or actual costs.

Such judgement is often exercised for a combination of political as well as economic reasons, and as with all political decisions the one to progress will normally be made based on widespread support for the potential benefits, that is, widespread in terms of those who contribute to the decision to support the work.

10.2.1 Difficulties in areas of interdisciplinary research and development

A complication arises for agendas that are based on interdisciplinary collaboration in that the range of contributing perspectives inevitably reduces the concentration of support. In particular, where an 'end-user' element is involved in the decision-making processes the perspective of benefits and timescales to address research issues will be different. Thus, the decision to approve a research agenda in terms of developing a new drug or surgical procedure is normally taken by a group with similar professional understanding, weighing different potential developments against each other and prioritizing between them.

Decision-making on research in the applications of ICT has only appeared to operate in this way where a perceived commercial return, in terms of product sales, is envisaged. Justification for investment is in terms of capturing a percentage of a potential market, etc. Where research is required to deliver in terms of a social agenda, the picture becomes more complex and the decisions have to be informed by support from the socio-political arena. Securing this support is an integral part of pursuing the research agenda.

The issue of timescales is vitally important here because the research with the highest impact is almost inevitably going to reach maturity when it has had a fundamental impact on the working practices of the very application constituencies whose support is required. Those supporting the research direction therefore have also to become knowledgeable about the implications of the work, and the potential impact on working practices as the research progresses. Indeed, concern over this impact and sensitivity to the implications is likely to be a serious component in determining continued support for the research directions and may well impact on the effective timescales involved. Too rapid a change in itself may lead to resistance to embarking on the direction of travel.

In order to share the definition of a common interdisciplinary research agenda, the perspectives of the contributing disciplines must all be discussed and a common, realistic understanding reached, which is likely to involve compromise. Issues which are likely to be at the top of an application domain's priorities are also likely

to be shorter-term considerations than the potential future directions which professionals in the ICT domain might envisage.

The contrast is often classed as 'technology push vs. application pull', but in truth the gap is wider than that and there tends to be little overlap in the two perspectives. The overlap tends to be in the engineering required to make practical use of the results of research by implementing a set of operational pre-conditions (e.g., agree standards or evaluate/educate business practices) before a genuine take-up can be achieved. In many cases the operationalization of research results requires extensive research in Stokes' fourth quadrant. For example:

– systematic investigation, analysis and classification of cultural heritage situations (e.g., design styles);
– agreement on generic standards for representing classes of object in digital systems.

Research in this quadrant tends very rarely not to achieve widespread acclaim and recognition, and hence tends rarely to attract the interest of career researchers (academic or otherwise). It is, however, a vital underpinning to the take-up of the highly visible, acclaimed prototypes of applications supported by basic research, which demonstrates principles, but does not achieve integrated coverage of the domain. Populating the field with systematic results is a potential area in which it might be beneficial to consider mobilization of community resources – in the same way as an open source community may contribute to the development and enhancement of a software system.

10.2.2 Difficulties in standards for interoperability

The issue is probably best highlighted in the area of standardization for interoperability. In the discussions reported in the previous section, virtually every grouping of cultural heritage professionals recognised the importance of standardization in the ways in which our knowledge of the past was archived. This will have a fundamental impact on the ability to design systems which can interoperate, for example, bringing resources together from a range of collections in order to respond to a need which an individual collection could not meet.

To many technologists the achievement of agreed technical standards is a tedious and time-consuming exercise which can only be undertaken after the research to demonstrate potential interoperability has been completed. Actually engineering a solution may be less interesting intellectually to the technological researcher, but is of fundamental importance to the business processes in the application domain, and to achieving market take-up of the research results.

To the application domain, the achievement of agreeing technical standards is a long-term goal and involves significant research on their part to understand the technical implications of the agreements being proposed. This process may well take several years and is normally an evolution as understanding is reached. The situation where, as is frequently quoted, "I like standards because there are so many to choose from" is a reflection of the continuing evolution of the proposed standards, as understanding of the implications of a particular set of agreements is realized in the application domain.

It is likely that the whole debate around the potential implications of a wide take-up of Dublin Core (and its derivatives) and/or CIDOC-CRM as an approach to documenting knowledge about museum collections will become a manifestation of evolving understanding, complicated by existing investments and political willpower(s).

These debates also fuel the decision-making processes for research investment and may fundamentally influence the directions taken in the underpinning technological research and the evolving priorities in research there. For example, the assumption that multi-lingual applications will be based on a common standard for the ontology describing a collection might lead to research in one style of search based on embedded semantics. If the choice of common ontology is different, new constraints and search metrics may well need to be developed, and if the technology domain has to operate with multiple standards concurrently, then a profoundly different approach might be needed.

None of these individual scenarios is yet a solved research area and each would take a different research programme to investigate it. The priorities for the technologists must depend upon those of the cultural heritage domain and they in turn can only take the decisions based on the advice on implications from the technologists. The process of evolving the agenda must be truly interdisciplinary in order to be maximally effective.

In the first year of the EPOCH project, the consortium tried to ease these communications difficulties by creating a number of showcases intended to enable a shared understanding of current potential applications and the work that would be required to realize them in a business-like context. This process continued through the project with the development and touring of the Interactive Salon and the production of 'KnowHow' books.

10.3 Different perspectives in the development of cultural heritage ICT applications

A common research agenda will also need to augment the core perspective on RTD with a view on the requirements, likelihood and time horizon of heritage organizations adopting the future ICT systems and applications that may stem from the ongoing RTD efforts. Such assessments and respective assessments will be of greater interest to stakeholders from technology companies and the heritage sector, as well as being useful for RTD planners and funding bodies.

Below we describe three perspectives which are important to consider with respect to the further development of market-near prototypes and potential uptake of new applications by cultural heritage institutions.

10.3.1 Technology companies

Technology companies develop, vend, implement and service technical systems and tools. With respect to the maturity life-cycle we distinguish between

(1) companies that are to a certain degree also engaged in technological research and development (RTD) activities, and
(2) companies that concentrate on marketing, implementing and servicing stable and proven technical solutions.

Both play an important role in the maturity life-cycle.

R&D-driven companies

The first group of companies forms an 'interface' between RTD, market, and innovation-oriented customers, i.e., the 'innovators' and 'early adopters' in the diffusion process of new technologies. Such companies develop prototypic systems and tools into marketable solutions. In any technology field, they are rare examples, particularly if there are no large enterprises that would license or buy and market the solution. This is the case in the field of cultural heritage ICT, where most of the companies are SMEs, and only little domain-specific specialization has taken place so far (e.g., in the area of collection management systems).

Some companies that engage in RTD activities and, among other target markets, deal with cultural heritage ICT, are spring-offs of university-based research centres. They build on results of some projects funded under various national and European programmes, and most often do not want to lose their foothold in the research community.

A typical example here may be EPOCH partner Imagination (Austria), which offers Virtual Reality services that include consulting, design, production of online interactive 3D applications and VR/AR installations for events, shows, exhibitions or permanent installations. The company is a spin-off of the Institute of Computer Graphics and Algorithms of the Technical University of Vienna. The institute participated in the long-term Austrian Joint Research Program on 'Theory and Applications of Digital Image Processing and Pattern Recognition' (1994–2000), funded by the Fund for the Promotion of Scientific Research. After Imagination was formed, it participated in FP5-IST projects such as 3D-MURALE (11/2000–10/2003) and has been one of the industry partners in the K-plus Competency Centre 'Virtual Reality and Visualization (VRVis)', funded by the Federal Ministry of Transport, Innovation and Technology.

On the European level also many other R&D-driven companies participated in the Fifth and Sixth Framework Programmes. In fact, 184 companies, most of them SMEs, participated in these programmes in the strategic priority of Cultural Heritage Applications.

Market-driven companies

The second group of companies concentrates on customers who are not in a position or willing to take any risk. Their role includes representing 'the face of technology' as mediated to such customers, who in the cultural heritage sector – as in any other domain – form the large majority of organizations.

The unfavourable business situation of the companies that target customers from the cultural heritage sector is described in the previous Report on the Common Research Agenda (EPOCH: D2.9, 2006). They have several major hurdles to take that include the different 'business culture' of cultural heritage institutions and professions, small IT-budgets, and lack of technical staff and background.

In practice, this can mean that CH customers sometimes use the companies for free consultancy, tenders may be ill defined, projects have long lead times and decision processes are not transparent. Expensive tendering exercises can lead to the cancellation of an initiative without appointment of a supplier, since it can often show an unrealistic perspective on the amount of investment required. Consequently, most of the technology companies do

not consider the CH domain as their core business. The degree of specialization is rather low, which leads to the situation of criticism that specific needs of the domain are often not met.

Results from a survey conducted in the framework of the EPOCH Sector Watch activity [EPOCH: D.2.1], section 2.2.2) confirm and detail this overall unfavourable situation. In particular it should be noted that many technology developers concentrate on prototypes in the sense that they are often only applied in one cultural heritage site or museum as a test case. Hence, the work on these prototypes does not necessarily lead to a marketable product that could be easily integrated by different cultural heritage institutions.

10.3.2 Cultural heritage institutions

When assessing the feasibility of cultural heritage institutions making use of advanced information and communication technology their capacity in terms of budget, staff, collections and users must be considered.

A study carried out by EPOCH partner Salzburg Research provides estimates of this capacity for small, medium-size and large institutions (Geser 2004). The study collected and analysed data from various surveys and other sources. The results are summarized in the following table:

	Small	**Medium**	**Large**
Annual operational budget in €	< 100,000	100,000–1 million	> 1 million
Staff in full-time equivalents (FTE); professional, support, volunteers not included	< 5 FTE	5-10 FTE	> 10 FTE
Number of collection objects	< 10,000	10,000–100,000	> 100,000
Number of annual visitors: for museums	< 7,000	7,000–30,000	> 30,000

Table 10.1: Characteristics of cultural heritage institutions of different sizes.
Note: The focus is to provide a better understanding of what distinguishes small from larger size institutions in quantitative terms. Therefore, the table does not include a category 'very large' or 'major' institution. Such an institution will typically have an annual operations budget of over €10 million

The study points out that most of the smaller and even many of the medium-size institutions, which together make up more than 90% of all organizations, will not find it easy to cover the total cost of ownership (TCO) for certain more advanced ICT applications beyond, for example, a simple Web site or a collection management system.

The most pressing factor that hampers heritage institutions in their efforts to leverage their IT environment is the lack of staff. A typical small institution will have fewer than five full-time equivalents, with only a fraction of them being professionals concerned with the institution's core business (e.g., curators, librarians, archivists, pedagogues).

Furthermore, smaller institutions' efforts in following up new technology ventures are limited by lack of financial leeway. A typical small institution will work on an operational budget of no more that €100,000 while a medium-size institution may have up to €1 million at its disposal.

Needless to say, these budgets leave scarcely any room to finance ICT projects out of the operational financial resources. For example, a survey conducted by Statistik Austria (2004) provides information about the ICT equipment of 389 museums and other institutions that exhibit cultural heritage objects. Of particular interest to EPOCH is the information on available computers in, and Web sites of, historical and archaeological museums. Of the 49 museums in this category 11 did not have a computer, 37 museums had one or more computers, which were used for administrative purposes (26 museums), Internet access (25), and collection management (19). Twenty-three museums also had computers in place for visitor information and 44 of the 49 museums had a Web presence through their own Web site (32) or/and on another Web site (13).

Institutions that are interested in developing and realizing more advanced technology projects will need additional funding. Yet, a common problem for small institutions is that, while the limited number of professional staff available may be able to ensure that the institution provides its core services, there will be little time to track down the necessary funds that would allow them to finance any ICT venture. And if they identify a suitable funding opportunity, they will find it difficult to prepare an application due to a lack of expertise in drafting a possibly

successful bid (cf. the results of the IMRI studies on the effects of the 'bidding culture' on local institutions in the UK (IMRI 2001 and subsequent reports).

Furthermore, experience from many initiatives shows that projects carry the risk of distracting institutions from core business and imposing activities that prove to be unsustainable after the funding period. Critics also point out that the majority of such projects favour financing the technological infrastructure, that is, the hardware and software equipment, over the development of the 'wetware', i.e., the technical skills of the programmers, operators and system administrators. The cost of ownership for the technological infrastructure is usually underestimated or not even considered.

Given the institutions' 'trilemma' of lack of funds, lack of human resources, and lack of technical skills, there is little likelihood of small to medium-size institutions being able to participate in research and technological development projects that develop new prototype applications and systems. Even the larger institutions may have difficulty engaging with projects to which they are required to bring their cultural and scientific heritage expertise and knowledge.

Some developments and issues in CH stakeholder needs

The following is a brief summary of observations regarding developments and issues in stakeholder needs by researchers of the Ename Center for Public Archaeology and Heritage (presented in the Research Agenda workshop at the VAST 2006 conference in Nicosia, Cyprus):

- On the local/regional level there exist severe weaknesses with respect to strategic planning and funding of CH initiatives;
- Some progress has been made with respect to equipping local and regional museums with computers and Internet access;
- However, local and regional content digitization initiatives are hampered by limited financial resources and a lack of relevant services;
- Much effort is invested in regional portals that provide information for cultural tourism purposes;
- More advanced virtual exhibitions are rare and institutional information is often only partial, not updated regularly, and most often not multilingual;
- However, priority must anyhow be given to the training needs of smaller and medium-size institutions with respect to capacity and skills for basic technologies (e.g., collection management systems);
- Many institutions could benefit from services of Centres of Expertise for which, however, business models or/and funding mechanisms must be developed.
- It should be noted that smaller and many medium-size CH institutions are not in a position to experiment with novel ICT-based approaches. They require tried and tested applications that look to deliver a clear cost/benefit ratio.
- For those who may be involved in the further development of useful applications the following factors will be of particular importance for successful projects:
- Application development teams must show a good understanding of the practical demands of CH institutions, hence, practitioners must be involved in the set-up of the development project;
- The target must be applications that have a likelihood of being adopted by many institutions beyond the initial project partners (in particular, this requires that the applications are robust and affordable);
- Priority will need to be given to a 'bottom-up' approach, starting with data collection and processing, lowering the cost of digitization, improving accessibility and usability of digital resources;
- This is closely related to the need of leveraging the inventory and collection management systems and external resource discovery, which can not be taken for granted for many CH institutions;
- Even for 'bottom-up' approaches considerable training of staff is required, which needs to involve experienced CH peers and be covered by extra project money (e.g., from regional funds).

Large vs. small museums: The case of Italian museums

According to the official statistics of the Italian Ministry of Cultural Properties and Activities (2005, section: *Presences in State museums and archaeological sites*) the following interesting facts can be noted:

- museums (out of 394) account for 50% of the presences;
- 20% of the museums account for 90% of the presences,
- one third of all museums have less than 20 visitors per day.

The first two findings are illustrated by the following Figure:

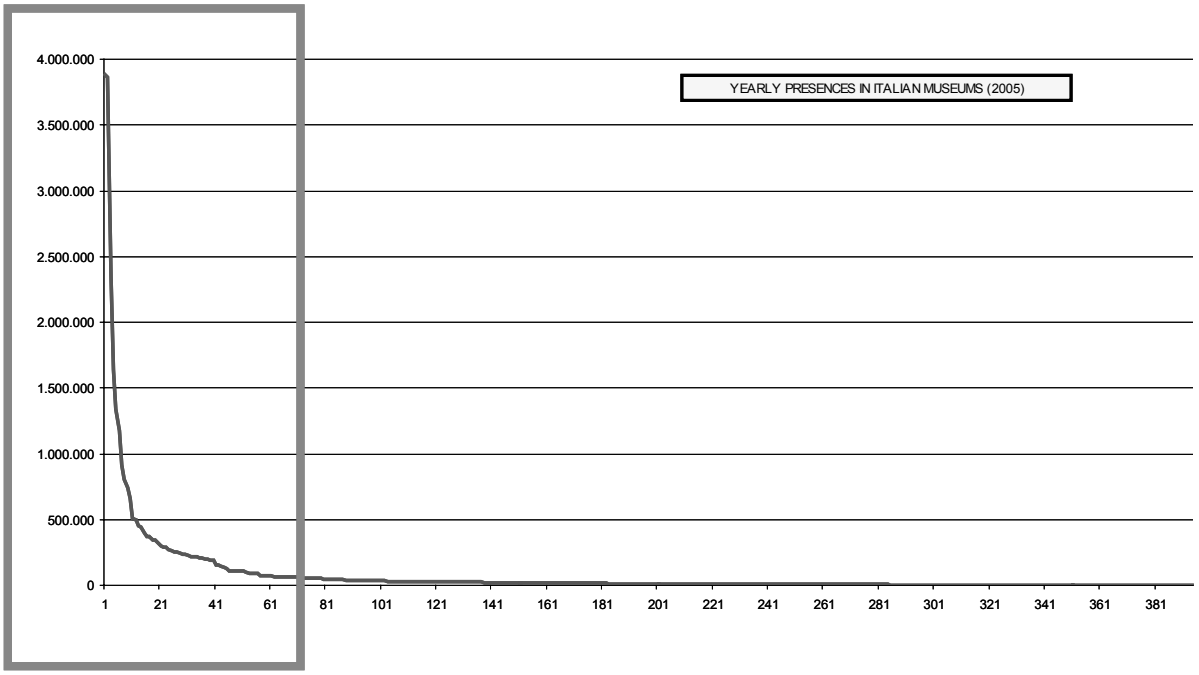


Figure 10.2: Distribution of presences in Italian State museums, 2005 (diagram by F. Niccolucci, PIN, Italy, data source: Italian Ministry of Cultural Properties and Activities 2005)

These visitor numbers clearly indicate a considerable imbalance of the distribution of public and cultural tourism interest in cultural heritage. Renowned larger institutions that are located in tourism centres and intensively market holdings and exhibitions receive most of the interest while smaller museums (with more valuable or less valuable collections) are neglected.

While differences in location, size, collections and exhibition activity must be noted, this also demonstrates a clear tendency towards 'cultural consumerism'. The statistics clearly show a visit pattern that is different from the one that is still widely expected by many cultural heritage institutions and funding bodies.

The observable imbalance between 'consumer behaviour' and 'cultural behaviour' (of educated visitors) should be noted, as this will considerably influence the presentation, and communication and interaction with users of CH museums and sites.

10.3.3 Cultural heritage expertise and service centres

Given the severe barriers of most cultural heritage institutions, there is a need to create structures that prevent them becoming blind spots in the rapidly developing digital environment. There is enough evidence that this environment of next generation systems and tools evolves at a rate much faster than the rate at which these organizations and smaller cultural networks can adopt and employ them (Geser 2004; Geser and Pereira 2004).

In fact, for smaller and medium-size institutions the benefits of most current and future technologies will need to be realized within national and larger regional initiatives. In such initiatives, a leading role will require to be played by new forms of cultural heritage expertise and service centres. There will, over the coming years, be an increasing demand for supportive digital services centres and ICT training programmes for technical and non-technical staff on how to handle new technologies. Such funded mechanisms should enable smaller institutions to keep the costs and risks of digital heritage resources and services manageable, while not being excluded from new technological developments.

The establishment of CH expertise and service centres could also lay the groundwork for the required much stronger linkage between research and technological development and CH experts and practitioners, which should be based on true interdisciplinary efforts. Particularly if such centres are established in conjunction with research centres that specialize in cultural heritage ICT, this may provide for a steady stream of knowledge between

researchers and technologists and experts and practitioners from – and clients of – cultural and scientific heritage organizations.

In a much more effective way, curators, arts and humanities scholars, educational programme managers and experts from cultural hotspots, such as historic city centres or larger heritage sites, could be involved in the development of prototypes of new applications, and feedback from professional users and visitors of sites, monuments and museums be collected. Model examples of cultural heritage expertise and service centres are the Dutch Digital Heritage Association (Vereniging DEN), which supports about 60 member institutions (cf. Van Kasteren 2003), or the smaller EPOCH partner Interactive Institute.

10.3.4 Discussion of stakeholder interest in certain CH ICTs

In the further elaboration and application of a CH ICT maturity life-cycle model it will be important to consider the level and direction of interest the different actors take in certain technologies because this interest will determine:

- which areas of RTD will receive the most attention by the research community in cultural heritage ICT (e.g., when forming new research groups or preparing research proposals),
- which systems and applications technology companies and digital CH expertise centres will propose to the institutions, and
- which systems and applications the different institutions in the field of tangible heritage will consider adopting.

General dynamics of stakeholders' interest

The following diagram provides a hypothetical assessment of the current interest of the research communities, technology companies, digital CH expertise centres and institutions in the technological areas covered by EPOCH's Common Infrastructure activity.

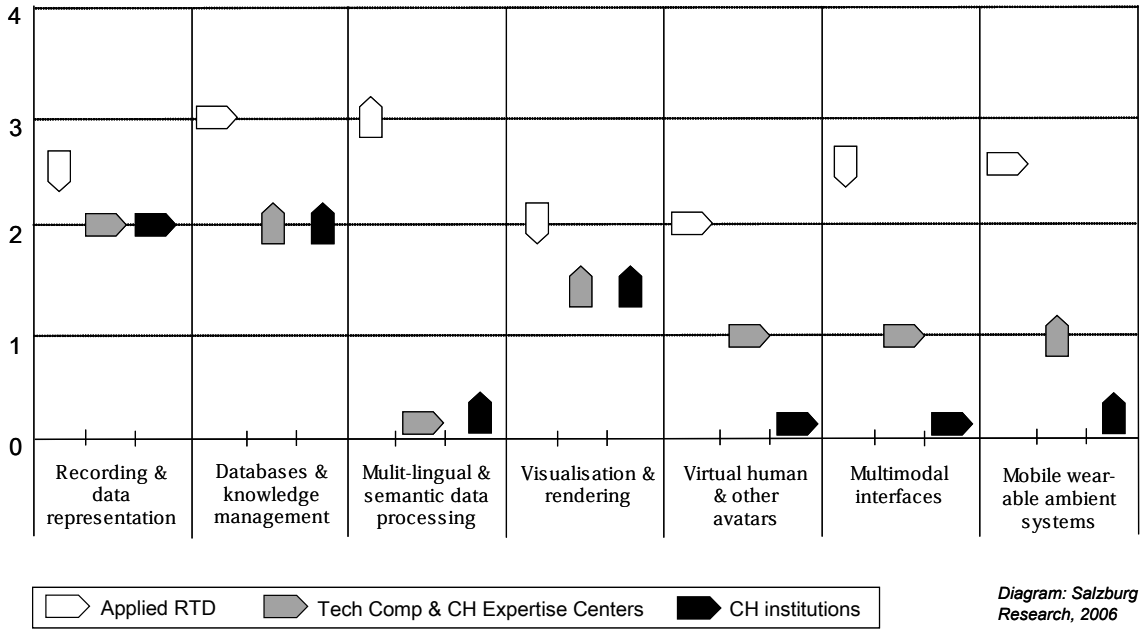


Figure 10.3: Hypothetical general stakeholder interest in selected fields of ICT applications

The purpose of this diagram is to illustrate some general dynamics that the Research Agenda will need to take into account, one such being that the different actors may show a stable, accelerating or declining interest in certain technologies.

For the research communities the interest may increase because of some new research priorities in major funding programmes that invite targeted research in the area. For example, this may be the case in the area of semantic data processing, where 'intelligent heritage' has been specifically addressed in the European Union's FP5 and FP6 as well as in some national funding programmes.

Alternatively, a decline in interest may be due to the observation of many researchers that a technology area is mature and provides only little further research potential. The area could even be already dominated and driven by commercial players.

One possible example for this dynamic is the area of 'visualization and rendering'. As shown in the 'EPOCH Pipeline Description' (EPOCH: D3.3.2, 2005, 32–38), in this area there exist high-end commercial tools, for example for 3D CAD (Pro/Engineer, SolidWorks, UGS SolidEdge) and modelling (3D Studio Max and Maya).

There are also solid open source 3D tools such as OpenCascade and Blender, and the commercial players offer academic and educational institutions excellent conditions. Further, there is an abundance of special tools, e.g., for terrain interpolation and landscape visualization.

With respect to the other actors we understand that there is on the one hand a rather close connection between which systems and applications technology companies and digital CH expertise centres will propose to the institutions, and what the institutions will actually consider adopting.

On the other hand, there may be some technology areas where companies and expertise centres would like to see a stronger interest from the side of the institutions (e.g., with respect to avatars, multimodal interfaces, and mobile wearable ambient systems).

The reason behind this is that CH technology companies and centres who also engage in applied research and development would like to be able to point to reference implementations of applications. They need reference customers from the CH sector in order to win over further potentially interested institutions. Only thereby can they capitalize on the know-how acquired in the show case projects, in which they often invest effort that exceeds the financial gains.

However, there may also be cases where (larger) heritage institutions and networks start to take an interest in a technology area, but most technology SMEs and regional CH competency centres will not command the required expertize to develop and implement a state-of-the-art solution (e.g., in the area of semantic data processing).

Institutional differences: Monuments, archaeological sites, and museums

Furthermore, it is important to take into account possible differences between the institutions in the field of tangible heritage. In the diagram in the previous section these institutions are grouped together and an overall assessment of the level and direction of interest in the certain technological areas is given.

However, when considering the differences between the institutions the following diagram may present a more appropriate, yet again, hypothetical, picture:

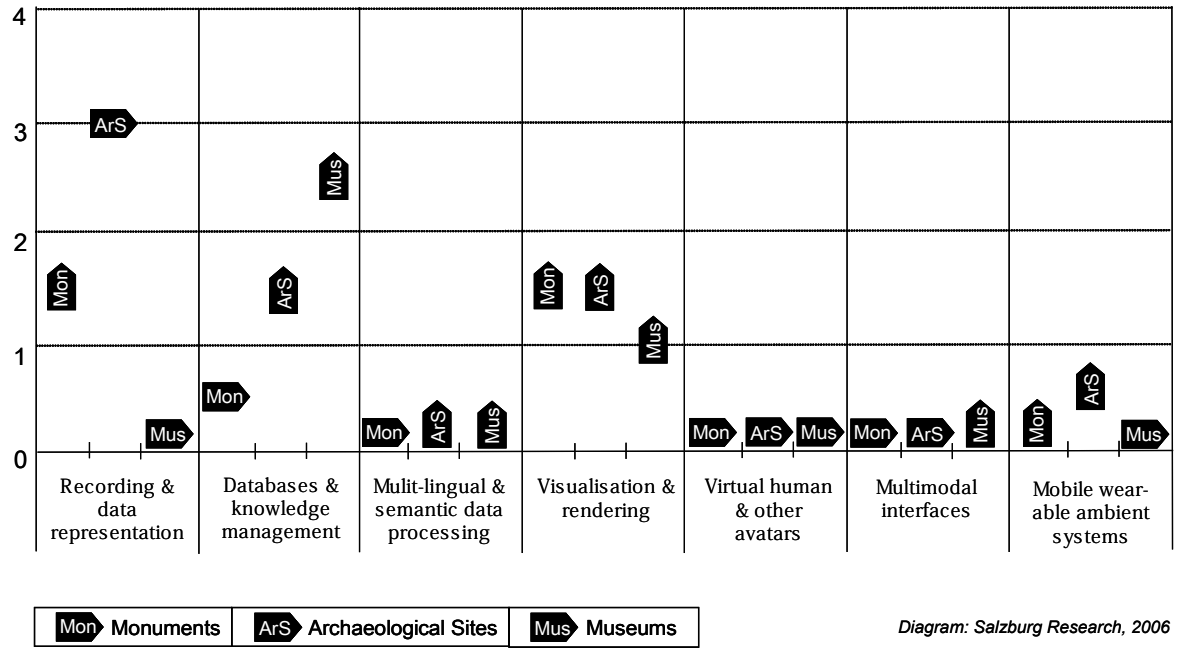


Figure 10.4: Hypothetical stakeholder interest in selected fields of ICT applications in different CH domains

Of particular interest here are the technology areas for which an overall assessment would level out the considerable differences in interest. Most notable are the first two areas.

In the area of 'recording and data representation', besides the continuing high interest of the archaeology community in this area, we observe a considerable rise in interest of monument managers in digital monitoring technologies able to detect changes in physical conditions, e.g., humidity, corrosion, decay of material, etc. (cf. the results of the EPOCH expert workshop at ICCROM Headquarters in Rome, 6–7 March 2006 (EPOCH, CHEDI, 2006))

On the other hand, the interest of museums in recording and data representation technology is low because most museums do not record, process and represent datasets such as archaeological field recordings, but digitize objects (e.g., 3D scans of museum objects such as statues) more as a means of presentation than as documentation of the sources and, hence, are much more interested in the technology area of 'visualization and rendering'. The impetus given by initiatives such as the European Digital Library, which emphasized a broader vision of collection digitization, may impact on the museum sector's interest in this area.

Finally, in the area of 'databases and knowledge management' we would expect a rather low interest at monument sites, at least in comparison with archaeological excavation areas and museums. The latter deal with large numbers of different finds or objects as well as currently striving to provide integrated access to the knowledge of experts in different subjects and results of ongoing scholarly research. A case in point here may be the considerable rise in interest in knowledge organization systems such as thesauri and ontologies in these domains.

Clustering of the interests in technological applications

The discussion in the above sections of course simplifies many issues pertaining to the aim of recognizing in a research agenda the interests of the different stakeholders:

- First, when considering the effects of the level and direction of interest the various stakeholders take in certain technologies, the interrelations between the technologies must also be taken into account.
- Secondly, for particular (prototypic) research or market-near systems and applications the technologies and interrelations between them must be detailed.
- Thirdly, for the (prototypic) systems and applications under discussion the perspectives and assessments of the different communities in cultural heritage ICT must be collected, analysed and clustered.
- Hence, the identification and prioritization of RTD challenges of different levels of ambition must start from a set of particular combinations of technologies as required for performing certain CH tasks. The degree of ambition may range from a considerable enhancement of the performance up to the realization of new technological platforms and attendant applications which allow for currently unachievable capabilities in cultural heritage research, management, and mediation (on 'grand challenges' in the computer sciences see (UKCRC) site and the cultural heritage ICT example by Arnold et al. 2006).

10.4 Business models for the transfer and wider deployment of new ICT applications in the CH sector

In the sections above we have introduced a maturity life-cycle for cultural heritage ICT applications and addressed the issue that the different stakeholder communities have differing perspectives of which technologies are mature enough to be adopted in the sector. In particular, this pertains on the one hand to research communities in basic and applied technological research and, on the other hand, museums and sites of tangible cultural heritage.

We have identified two chasms in the diffusion of research results:

Chasm 1: This chasm concerns the transfer of 'near market' ICT prototypes to innovators and other early adopters in the CH sector. This transfer is hampered by the following situation: 1) there are only few research-driven companies that develop results of applied research into robust working solutions for the target market CH, and 2) this market is not characterized by strong incentives for seeking a competitive advantage as well as capability for the risk-taking that is required when adopting novel applications that have not so far proven their benefits.

Chasm 2: This chasm concerns the adoption at a late stage by many institutions in the CH sector of a more mature application, a whole product with additional features and ancillary services. The main problem here is that most CH sector institutions are small organizations that lack technical staff and support and are not able to cover the total cost of ownership for ICT applications from their operational budget. Many of them would be happy enough if they could afford a state-of-the-art website, have in place a better collection management system or could enhance exhibitions with interactive displays.

In order to overcome these chasms, novel business models need to be investigated that allow for a achieving a higher level of adoption of prototypic and mature ICT applications by organizations in the CH sector.

10.4.1 Models for the transfer of new knowledge and technology from applied research and development

In the valorisation of the investment in dedicated research on ICT applications for the CH sector, special attention must be given to feasible approaches in the knowledge and technology transfer from universities and research centres to SMEs. This transfer is crucial for ensuring the uptake of results that stem from applied R&D in ICT.

It is often thought that this uptake could be directly effected by cultural heritage organizations. But innovative technology developed at universities and research centres typically will not have the maturity or necessary specific features to be easily deployed by these organizations, e.g., essential parts of a workflow may be solved by separate tools or not at all.

A larger number of spin-off companies based on prototypic applications specifically developed for CH purposes is rather unlikely, because the CH sector is known to be a difficult market and hardly can be considered as a company's core field of business. This is due to a number of reasons, e.g., small IT-budgets, lack of technical expertise, 'different business culture', long lead time of projects, etc. Therefore it is clear that the CH sector does not specifically invite entrepreneurship by academic research centres. This also may have added to a tendency to believe that research projects in CH ICT are finished off by simply making results available through a Web site as Open Source software, with no related effort to nourish a committed developer and user community.

Though, as can be seen from trade fairs and exhibitions (e.g., Exponatec Cologne – International Trade Fair for museums, conservation and heritage; Tile – Trends in Leisure and Entertainment) or exhibitor spaces at some conferences (e.g., CAA – Computer Applications and Quantitative Methods in Archaeology) there are quite a number of companies who have developed expertise, products and services for this market.

One strategy that could allow for a better valorization of research prototypes is to establish relationships with such companies and acquire a better understanding of requirements for turning prototypes into market-ready applications. For example, there may be specific issues of stability, missing features, usability, and required ancillary services for creating a 'whole product'.

Generally the transfer of ICT knowledge and technology, both hardware and software, developed by universities and research centres must go to organizations that have sufficient basic expertise in the field of technology under consideration. Models for this transfer can be:

- *Service-based transfer:* In this model the application is Web based (such as the EPOCH 3D Web service) and accompanied by training and other services for SMEs that are active in the CH market (e.g., detailed documentation, helpdesk, temporary direct support);
- *Co-development-based transfer:* Typically this would take the form of a development partnership of a research centre and a SME for creating a market-ready solution from a research prototype, taking care of issues such as interoperability, scalability and additional features that CH workflows may require;
- *Public–private expertise centres:* In this model, a centre is established that brings together research groups, technology development companies, and implementation and support units from the CH sector (e.g., from a regional CH network or major institutions). The activities of such a centre or cluster would cover the whole spectrum of technology-transfer, application development and implementation, and technical support for CH institutions.

All three models allow not only for an enhanced transfer of new knowledge and technology, but, at the same time, will enable research centres to gain a better understanding of market demands. Expertise centres that include technology implementation and support units from the CH sector could also foster a higher degree of use-inspired research as they provide a direct link into the CH sector.

This is also one reason for EPOCH partners to establish a network of centres of expertise in CH ICT, in particular, for applications whose development and implementation requires expertise that cannot easily found on the market (e.g., 3D virtual environments). Such centres typically will be established by, or in close collaboration with, research centres that specialise in CH ICT in order to allow for a steady stream of knowledge between researchers, companies and experts from the CH sector.

10.4.2 Business support models for SME and social enterprises in CH ICTs

SMEs and social enterprises could play a more important role in implementing and servicing applications and digital resources of heritage institutions on the local and regional level. Some specialised SMEs already provide services such as photogrammetry and 3D data acquisition, multimedia solutions, and virtual reality applications. However, it is well known that it is very difficult for SMEs to survive operating only in the heritage market. Many consider it only as an extra outlet on top of other core activities, which leads to a situation in which specific needs of the domain are met only partially.

SME support seems required to leverage opportunities for business development and fruitful collaboration with heritage institutions. A situation where tools, methodologies and guidelines for the creation of digital collections and applications are available, but the heritage domain lies dormant because heritage professionals do not have necessary expertise and skills and companies cannot see profitable opportunities clearly would be most undesirable.

Among the business models that need to be investigated are:

- *Business development support – incubators:* Business incubators generally provide support in the development of a business plan, business set-up, office spaces, external services (e.g. legal advice, accounting, etc.), and offer training in required skills (e.g., business management, financing, etc.). Moreover there may be a focus on certain industry sectors. An example for this strategy is the project Incubator, 'a greenhouse for small companies working with digital media for cultural heritage', of the EPOCH partner Swedish Forum for Cultural Heritage. As the first of its kind in Sweden, Incubator offers a flexible and creative workspace where small companies can grow and develop their business, in part by working on projects that are initiated by Incubator or external bodies. The project offers training, a shared space, professional assistance and workshops/seminars.
- *Location of small CH ICT companies in creative clusters:* Such clusters pool and stimulate synergies between a variety of creative resources such as media centres, arts venues, cultural institutions, non-profit cultural enterprises and individual artists. Often such clusters have shared infrastructure that provides support for projects and the presentation of results. A good example of such an infrastructure is The Media Centre in Huddersfield, UK, which originated from the Creative Town Initiative (http://www.the-media-centre.co.uk).
- *Formation of a social enterprise:* In the previous section we addressed the model of public–private expertise centres that also comprise CH ICT implementation and support units. Typically such units will be established as social enterprises that to a larger part are publicly funded to provide services that would not otherwise be affordable by small CH institutions.

Making use of such models basically is about both creating business development opportunities for small companies in a region and ensuring that specific needs of the CH domain are better met than is often the case today at the regional and local level.

It may also be worth noting that the 'not-for-profit' character of many organizations in the cultural heritage sector appears to extend to many of the SMEs involved in the sector where they are commonly led by individuals who are passionately committed to the cultural heritage sector and regard profit as necessary in order to survive but not 'the reason for being involved'.

10.4.3 Strategies for technology transfer, market development, and uptake of solutions that work in CH practice

Valorization of the investment made by the public hand in the research and development for innovative ICT applications for specific sectors like cultural heritage is an important point on the agenda of policy-makers and funding bodies. Furthermore, public agencies and business associations often will ask what they could do to help make public sector organizations more 'e-ready' and create business opportunities in the cultural sector. Therefore this section summarizes some important considerations and recommended approaches.

Tackle roadblocks in the exploitation of R&D results

The mechanisms required for ensuring an effective exploitation of R&D results need to be considered more thoroughly. In recent years a lot of progress has been made – for example, by projects funded under the Fifth and Sixth Framework Programmes – that has yet to achieve its market penetration potential.

In fact, the roadblocks on the way from research prototypes to applications that work in CH practice and are adopted by many organizations are huge. In most technology areas these are overcome by companies that form an interface between R&D and innovation-oriented organizations. They develop prototypic applications into market-

ready solutions. However, such an interface has not so far evolved to a sufficient degree in the field of cultural heritage ICT.

Spring-off companies of university-based research centres based on prototypic applications specifically developed for CH purposes are rather unlikely. But the often-found practice of just making results available through a Web site as Open Source software is not a solution to the problem. There needs to be a committed developer community, including the original creators of the software, who take care of maintaining, further developing, and servicing the software. Another solution is a transfer of research results – software, prototypic devices, etc. – to companies who might develop new or enhanced products or services based on them.

Investigate more effective models for the transfer of new knowledge and technologies from applied research and development

Results from applied research and development such as ICT prototypes usually cannot be directly taken up by CH institutions. Rather, a transfer is required to organizations that develop market-ready solutions and offer services (implementation, maintenance, upgrades, etc.).

Models for this transfer comprise, but are not limited to,

– Web-based services and accompanied training and other services;
– co-development partnerships, and
– public–private expertise centres.

Although knowledge and technology transfer is crucial for reaping the benefits of dedicated, use-inspired research on ICT applications for the CH sector, little is known today about the current use and effectiveness of these different models. Therefore an effort should be made to identify, gather, summarize and disseminate experiences that have already been made in the application of these models.

Gain a better knowledge about the CH ICT market and companies that operate successfully in this market

The CH sector is understood to be a difficult market for a number of reasons, e.g., small IT-budgets, lack of technical expertise, 'different business culture'. In practice, this can mean that CH customers sometimes use the companies for free consultancy, tenders may be ill-defined, projects have long lead times, etc. Consequently, most technology companies do not consider the CH domain as their core business. The degree of specialization is rather low, which leads to a situation in which specific needs of the domain are often not met.

Though, as can be seen from trade fairs or exhibitor spaces at relevant conferences, there are quite a number of companies who have developed expertise, products and services for this market. Some companies also participate in European and national research programmes. For example, in the Fifth and Sixth Framework Programmes 184 companies, most of them SMEs, participated in the field of Cultural Heritage Applications. In order to establish effective ways of moving research prototypes closer to the CH ICT market, a better knowledge of this market should be acquired and relationships established with companies that already operate successfully in this market.

Establish cultural heritage ICT expertise and service centres

EPOCH has identified the need to establish CH ICT expertise and service centres, in particular, for applications whose implementation requires expertise that cannot easily found on the market (e.g., 3D virtual environments). In addition, smaller CH organizations would need much support in order to benefit from new technological opportunities (Geser 2004).

The establishment of CH ICT expertise and service centres could lay the groundwork for the required much stronger linkage between applied R&D and CH experts and practitioners, which should be based on true interdisciplinary efforts. Particularly if such centres are established in conjunction with research centres that specialize in CH ICT, this may provide for a steady stream of knowledge between researchers, technologists and experts and practitioners from – and clients of – cultural and scientific heritage organizations.

In a much more effective way, curators, arts and humanities scholars, educational programme managers and experts from cultural hotspots, such as historic city centres or larger heritage sites, could be involved in the development of prototypes of new applications, and feedback from professional users and visitors to sites, monuments and museums be collected.

Promote sharing of lessons learned in business support models for SMEs and social enterprises in the CH sector

On the regional level a strategy is recommended of combining the promotion of cultural and creative SMEs with the aim of serving ICT needs of museums and sites. Such needs range from state-of-the-art interactive Web sites, including virtual presentation of a site, exhibitions, etc., to more CH-specific applications and services.

Public administrations and agencies who want to leverage the 'e-readiness' of the region will support business incubator projects that focus on CH digital resources and innovative Web and other solutions, promote a closer collaboration of SMEs and museums within creative clusters, and support social enterprises that specialize in CH-specific applications and services.

Lessons learned from making use of such models should be collected and shared among regions throughout Europe.

11 Socio-economic research themes in tangible cultural heritage and ICTs

11.1 Introduction and overview

The following sections will centre on socio-economic themes of the Research Agenda. Most of these themes concern issues in the valorisation of tangible cultural heritage such as heritage sites, historic town centres, monuments and museum collections, and the role ICT applications can play in this valorisation.

Within the EPOCH project, one activity has centred on research into the socio-economic impact of cultural heritage and the contribution to that impact that may be realized with appropriate use of technologies. This activity has resulted in a series of events and publications prepared by the CUBIST (Cultural Business: Impact, Strategy and Technology) research group based at the University of Brighton. (McLoughlin, Kaminski and Sodagar 2006, 2007a,b).

Furthermore, EPOCH consortium partners have led or participated in projects under the INTERREG programmes that aim at promoting regional development and competitiveness. With respect to historic towns and sites, the European Association of Historic Towns and Regions has coordinated the INHERIT project that produced a major Guidance Report on heritage-led regeneration (INHERIT 2008); Salzburg Research within the Hist.Urban project has carried out a study on the role of cultural tourism for historic towns and regions in the experience economy (Geser 2007a, b).

It should be noted that there have been a large number of other relevant projects under the INTERREG and other programmes, for example, the PICTURE (Pro-active management of the Impact of Cultural Tourism upon Urban Resources and Economies) project under the FP6 Integrating and strengthening the European Research Area programme and the URBACT Culture project under European Community initiative URBAN II. PICTURE aimed to develop an urban governance framework for the sustainable management of cultural tourism within small and medium-sized European cities, while URBACT Culture explored the role of cultural activities and creative industries as driving forces for urban regeneration. (cf. the overview on related projects in Geser 2007c)

In this chapter primarily results of the research work, including identified further research needs, by EPOCH consortium partners are presented.

Issues in the quantification of the impact of cultural heritage and ICTs

There are many direct and indirect values and benefits associated with physical cultural heritage assets, for example, property prices, inward investment potential and the general feeling of wellbeing of the citizenry have all been identified as positive impacts of valued heritage environments.

It is clear that cultural heritage has intrinsic value for those to whom the heritage relates. For example, a study has been conducted of the value placed on the Brighton Pavilion (UK) by residents of, and visitors to, the city. This building, which is less than 200 years old, is nevertheless iconic and considerable economic value is placed on it, whether or not those surveyed actually visited the site (McLoughlin, Kaminski and Sodagar 2007a, 86-97).

The socio-economic impacts of physical cultural heritage, and its on-site and online communication, are difficult to measure, but are provably positive. However, even though some of the positive contributions may be difficult to quantify there is no doubt that the combined value of cultural heritage at the macro level across Europe runs into billions of euros.

The most obvious example is the tourism sector, which is worth hundreds of billions of euros in annual turnover in Europe. For example, in 2006 Europe had 460.8 million international tourist arrivals, which generated estimated receipts of €298.3 billion for tourism businesses, excluding international passenger transport (WTO 2007b). Fifty-one per cent of all arrivals were for purposes of leisure and recreation. Cultural landscapes, historic town centres, museums, monuments and other heritage sites not only are often the backdrop for, or purpose of, many visitor activities, but are certainly also one of the motivators for choosing a European travel destination in the first place.

Europe spends many billions annually on the education of its citizens, a component of which is in their education as citizens engaged in their history and heritage. The interest and participation of citizens in cultural heritage is considerable, as shown by the important role of volunteers in the sector (Heritagelink 2005) as well as plain visitor numbers. For example, a study on major cultural institutions in the UK found: “There are over 42 million visits

each year to major museums and galleries. It is more than attendance at the Premiership League plus the whole of the rest of league football for 2004–05" (Travers 2006).

What is hard to quantify, though, is the impact that individual investment choices have on the 'value added' by cultural heritage. In part this is because the incremental effect on value in a country, region or town may be difficult to isolate and in part it is because the macro-level economic advantage may not be directly realized by those organizations which make the investment.

This also, and maybe even more so, applies to the investment in ICTs and digital content in the cultural heritage sector. ICTs allow for managing, promoting and communicating cultural heritage assets and historical and cultural knowledge in novel ways that add to, often enhance, and sometimes challenge established practices. For example, they enable CH institutions to reach and communicate with traditional and new constituencies in ways that were unimaginable two or three decades ago. But the impact of the learning, enjoyment and creative inspiration that this allows is difficult to evaluate in socio-economic terms.

There are also questions of how to make good use of ICT applications and digital content in the valorization of tangible cultural heritage (e.g., best practices and benchmarks). But they will often not allow for generating a direct financial return. Therefore, in the first place a higher commitment of stakeholders for investing in physical cultural heritage may need to be promoted through demonstrating its benefits for a number of goals of countries, regions and towns. There is a promise that ICT applications and digital content can leverage these benefits, but the question is how significant these benefits are. This means that wider strategic frameworks such as regional development and competitiveness must be considered within which cultural heritage and ICTs can make a particular contribution.

Valorisation of cultural heritage

Valorization of cultural heritage here is understood as activities that aim at optimizing the contribution of cultural heritage to the societal goals of sustainable economic growth and employment (Lisbon Strategy), in particular, through realization of growth and employment in the sector and related cultural and other sectors (e.g., tourism, creative industries), and through contributions to urban and regional regeneration, education and skills development, cultural participation, and social cohesion.

The following Figure gives an overview of relevant actors and fields of valorization of tangible cultural heritage:

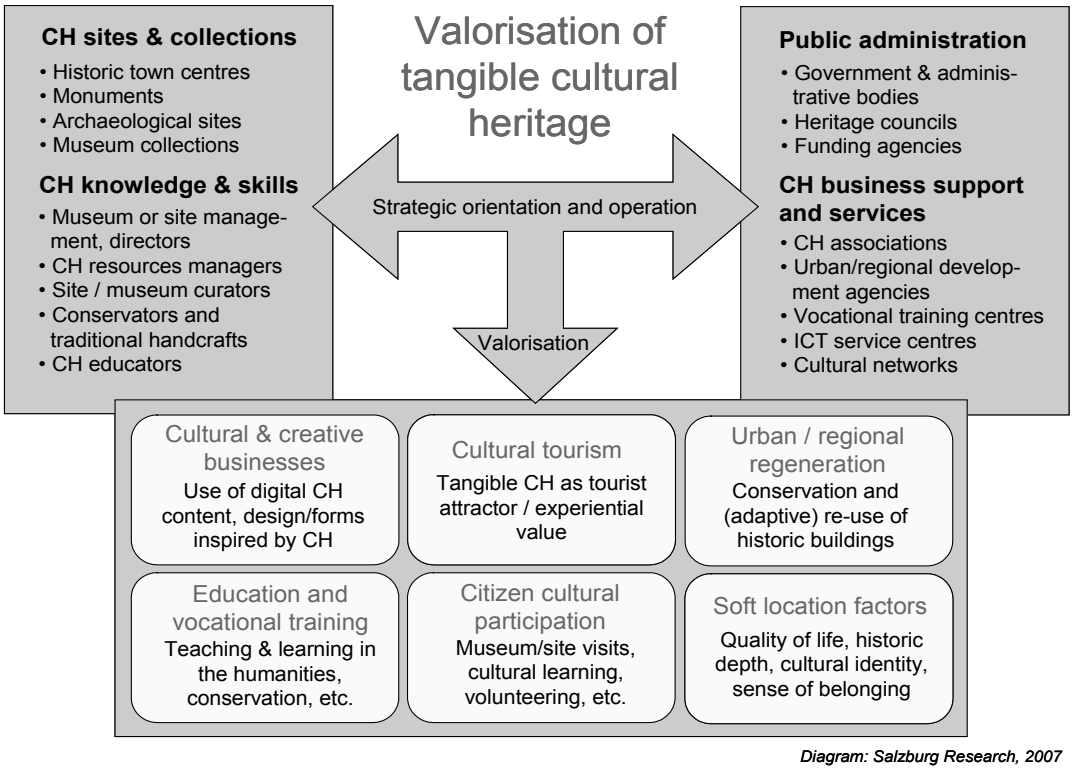


Figure 11.1: Valorisation of tangible cultural heritage

The Figure emphasizes that the valorization of tangible cultural heritage assets requires a common strategic orientation and operation of heritage institutions, public administration and various business support and services organizations.

The box in the lower part of the Figure shows different components of the overall valorization of cultural heritage assets, which also include specific sectoral knowledge and skills. These components can be directly or indirectly related to the spectrum of activities of museums and institutions that manage archaeological sites, monuments or historic town centres. For example, according to the ICOM definition a museum is an institution "in the service of society and of its development, and open to the public, which acquires, conserves, researches, communicates and exhibits, for purposes of study, education and enjoyment, material evidence of people and their environment" (ICOM, http://icom.museophile.org/definition.html).

The inclusion of cultural and creative businesses and cultural tourism in the overview does not mean that CH institutions should become leading commercial players in these fields. Rather, that their assets allow for a commercial valorization, in which the institution may or may not partake to a considerable degree.

The contribution of the general educational function of CH institutions is included under citizens' cultural participation. Noted separately is the contribution to tertiary education and vocational training by many academic, specialized and highly skilled professionals of the cultural heritage sector.

We also emphasize the contribution cultural heritage makes to soft location factors such as cultural identity, quality of life and sense of belonging. While museums and sites will rarely be a determining factor in locational decisions of businesses and individuals, their presence can still be an important secondary factor.

Overview of this chapter

In what follows, we:

- present some socio-economic information that should make clear the relevance of the culture and heritage for the Lisbon Strategy, particularly including the importance of tangible cultural heritage for the European tourism sector and the social and economic regeneration of regions and towns;
- note the profound changes in the notions of culture and heritage in modern societies and that cultural diversity has become a core paradigm of cultural heritage policy (cf. 'Our Creative Diversity' from the World Commission for Culture and Development (1996) and the UNESCO Convention on the 'Protection and Promotion of the Diversity of Cultural Expressions' (UNESCO 2005));
- identify some basic issues in a socio-economic research agenda for CH and ICT that pertain to appropriate models and empirical data for policy making and decisions on investment in the preservation and promotion of cultural heritage, adoption of ICT applications in the heritage sector, institutional capacity building, etc;
- present concepts, approaches and examples for capturing the socio-economic impact of cultural heritage, such as 'heritage value' and 'total economic value' of cultural heritage, economic impact assessment of heritage sites, and 'non-market' valuation of heritage;
- address issues in the development of sustainable cultural tourism by summarizing favourable and critical aspects and identifying needs of further research and advice on sustainable tourism development;
- finally, it is suggested that ICT applications can play an important role within an integrated development of historic towns and sites; the example of developing a 'cultural city' environment with high experiential value for visitors and residents alike is used to present a number of development options of historic towns, including use of available as well as emerging ICT applications.

11.2 Contribution of the domains of tangible cultural heritage to the Lisbon Strategy

The most important European policy framework with respect to the socio-economic relevance of tangible cultural heritage is the Lisbon Strategy. Launched by the European Council in Lisbon in March 2000, the Lisbon Strategy states that the European Union should become "…the most competitive and dynamic knowledge-driven economy in the world by 2010, capable of sustainable economic growth with more and better jobs and greater social cohesion". The European Council in Gothenburg in June 2001 stressed the goal of sustainable development and added an environmental dimension to the Lisbon Strategy. The revised Lisbon Strategy of the European Council in March 2005 emphasized the realization of stronger, longer-lasting growth and reinforces the goal to create more and better jobs (EC 2005b).

The cultural sector, of which the domains of tangible cultural heritage are but a small part, is increasingly seen to be of strategic importance for economic growth and employment in Europe. Besides the performance of the

sector itself (figures are presented below), also the relevance of its indirect impacts on the overall performance of the economy must be noted:

- The cultural sector is understood to make a considerable contribution to the take-off of ICTs, the flagship industry of the Lisbon Strategy: the sector provides content to fuel digital devices, networks and services, thereby contributing to the adoption of ICTs by European citizens;
- The wealth of cultural institutions, performing arts and cultural events also constitutes a powerful catalyst for attracting tourists, thereby complementing the tourism industry, which is particularly well-performing in Europe;
- Furthermore, the cultural sector is understood to provide important contributions to sustainable regional and local development. For example, activities of cultural organizations at the local level can have significant impacts with respect to social regeneration and cohesion.

The Lisbon Strategy includes the goal to make the European regions and cities more attractive places to work, live and invest. The largest part of the population lives in urban areas, which are also the location of most jobs, businesses, higher education and cultural institutions. The key role of these areas for economic growth, employment and territorial cohesion has been emphasized by the European Commission in its Communication to the Council and Parliament on 'Cohesion Policy and cities: the urban contribution to growth and jobs in the regions' (EC 2006d).

This Communication was issued on 13 July 2006 and provided proposals for actions related to the Community Strategic Guidelines on Cohesion (see below). The proposals for actions cover a large number of areas that reflect the possibilities for national strategic priorities and regional operational programmes related to the European Structural Funds. The Communication with respect to the goal of 'attractive cities' considers four areas for actions: transport, accessibility and mobility; access to services and amenities; the natural and physical environment; and the cultural sector.

The proposals for actions concerning the cultural sector state:

> "Cities – through a sustainable cultural policy – should promote a vibrant culture, based on the availability of facilities such as cultural and scientific centres, historic quarters, museums, libraries and the preservation of the architectural and cultural heritage. These facilities, along with a programme of cultural activities, including for young people, make the city more attractive to citizens, businesses, workers (especially mobile and highly qualified workers) and visitors, and strengthens the image of the city, local pride and identity. Moreover, culture – and cultural tourism – is in itself a rapidly growing industry."

Furthermore, the role of an active cultural policy as "…a valuable tool for building bridges between communities and fostering the integration of immigrants and other newcomers to the city" is noted (EC 2006d, 6 – 7).

The Community Strategic Guidelines on Cohesion, which were determined by the Council of the European Union on 6 October 2006 (2006/702/EC), contain the principles and priorities of cohesion policy and suggest ways the European regions can take full advantage of the Structural Funds of €308 billion that have been made available for aid programmes for the period 2007 to 2013. The Guidelines promote an integrated approach to cohesion policy so that it not only encourages growth and jobs, but also pursues social and environmental objectives. They provide an important basis for the member states in drafting their national strategic priorities and planning for 2007–2013, the so-called National Strategic Reference Frameworks (NSRFs).

A paragraph of the Decision of the Council of the European Union emphasizes that:

> "…measures are important that seek to rehabilitate the physical environment, redevelop brownfield sites especially in old industrial cities, and preserve and develop the historical and cultural heritage with potential spin-offs for tourism development in order to create more attractive cities in which people want to live. The regeneration of existing public spaces and industrial sites can play an important role in avoiding suburbanization and urban sprawl, thereby helping to create the conditions necessary for sustainable economic development. More generally, by improving the planning, design and maintenance of public spaces, cities can 'plan out' crime, helping to create attractive streets, parks and open spaces which are safe and feel safe. In urban areas, the environmental, economic and social dimensions are strongly interlinked. A high quality urban environment contributes to the priority of the renewed Lisbon Strategy to make Europe a more attractive place to work, live and invest" (Council of the European Union 2006, 30).

With respect to rural areas the Council particularly stressed the importance of economic diversification and the key role of tourism for such areas, which require well-balanced measures in the preservation and development of natural and cultural assets:

> "Many rural regions depend heavily on tourism. These regions require an integrated approach dedicated to quality, focusing on consumer satisfaction and based on the economic, social and environmental dimensions of sustainable development. Actions should take advantage of, and seek to preserve and develop natural and cultural assets which can have important positive spin-offs by protecting habitats and supporting investment in biodiversity. The integrated approach should aim to have a positive impact on the tourism sector, the local economy, the people working in the tourism sector, visitors and the local population, as well as the natural and cultural heritage" (Council of the European Union 2006, 31).

It may be interesting to note that during the financing period 2000 – 2006 of the European Regional Development Fund (ERDF) many regions devoted priorities or measures of their operational programmes to culture, cultural heritage and related activities. A Commission Staff Working Paper from 2007 notes that Greece and Portugal:

> "…were running entire operational programmes on culture. The 'Culture' objective 1 programme for Greece sought promoting the protection and development of the cultural heritage and the development of Greece's modern culture as priorities, with a budget of EUR 675 million, of which EUR 474 million coming from the ERDF and the remainder from other public and private sources. The 'Culture' operational programme for Portugal had the development of historical and cultural heritage, and an improved access to cultural sites and activities as priorities, mobilizing EUR 351 million in total, of which EUR 249 million contributed by the ERDF. For the 313 draft operational programmes for 2007–2013 received so far by the Commission, planned expenditures for culture amount to more than EUR 5 billion, of which 2.6 bn for protection and preservation of cultural heritage, 1.8 bn for the development of cultural infrastructure, and EUR 590 million for assistance to improve cultural services" (EC 2007g)

The following sections present socio-economic information on the relevance of culture and heritage for the Lisbon Strategy, including their contribution to the social and economic regeneration of regions and towns.

11.2.1 Contribution of the cultural sector and cultural heritage domains to growth and employment

Cultural heritage within the wider cultural sector

Statistical figures for 'the cultural sector' or 'cultural employment' in Europe that are presented in a number of studies are calculated from aggregations of available national data on selected sub-sectors, industries, occupations, etc. There is insufficient space available here to discuss the intricacies of the data sources and delineations that are used in this work.

What should be noted, though, is that the statistical work is informed by certain notions of what is to be understood by 'cultural'. There is a rather good consensus on this among statistics organizations because of the work of UNESCO's Institute for Statistics (Culture Statistics Programme, and its re-evaluation from 2002 onwards), the Working Group on Culture Statistics of the European Union (until 2004) and other international work on a common framework.

The situation has been complicated by the policy interest at the national and EU levels in the so-called 'creative industries'. Since the first Creative Industry Mapping document was published in the UK in 1998 many European countries have commissioned studies on the scope and economic relevance of theses industries for purposes of policy definition (cf. Braun and Lavanga 2007).

Recent statistical and study work centres on the 'creative sector' or 'cultural and creative sector', in which commercial media production and delivery, design and architectural services, performing arts, and cultural heritage and memory institutions are lumped together; though, at least, general advertisement, the computer and software industry, and activities in research and development are not usually included.

It has become clear for many observers that such a combination of domains loses sight of essential differences, e.g., commercial versus publicly funded; artistic or design creativity versus public service, etc. This seems unlikely to allow for good policy making, and is potentially harmful (Gordon 2007; Holden 2007). A better approach may be to acknowledge the differences and seek to strengthen those fields of activity where there are productive relationships, influences and synergies within a complex ecology that has in recent years become ever more dynamic, not the least because of the impact of ICTs and digital production and distribution chains.

In this context it may be worthwhile to emphasize that cultural heritage institutions such as museums should not be seen as belonging to the cultural or creative industries. Such organizations are part of the larger cultural sector, but do not carry out industrial cultural and creative activities aimed at bringing to the market novel products. Rather, cultural heritage comprises various resources that can be used for commercial purposes or can have an enabling or supportive role in economic activities.

For example, the Victoria and Albert Museum (London) has rich collections of British craft, design and manufacture, and its staff is very creative in presenting and communicating them. The museum's purpose is "…to enable everyone to enjoy its collections and explore the cultures that created them; and to inspire those who shape contemporary design" (Victoria and Albert Museum (London) Web site). Indeed, the primary role of cultural heritage collections will be to promote learning, enjoyment and creative inspiration, while this may also help to stimulate creative production of cultural and other goods, cultural tourism and other purposes.

Contribution of the cultural sector to the EU GDP

The Study on the Economy of Culture in Europe (KEA 2006), commissioned by the European Commission, carried out a comprehensive analysis of the cultural sector, including the full range of organizations from publishing industries to cultural institutions. According to their figures, the cultural sector in the EU25 in 2003 turned over more than € 654 billion, a contribution to the EU Gross Domestic Product of 2.6%.

The relative importance of the sector becomes more apparent when its value added to Europe's GDP is compared with that of other industries. For instance, the contribution in 2003 of real estate activities (including the development, buying, selling and letting of real estate) accounted for 2.1% of Europe's GDP, chemicals, rubber and plastic products industry for 2.3%, and food, beverages and tobacco manufacturing for 1.9%. The overall growth of the cultural sector's value added in 1999-2003 was 19.7% whilst the nominal growth of the European economy in this period was 17.5%; this means that the sector was a positive driver for development in Europe.

Cultural employment in Europe

The Study on the Economy of Culture in Europe (KEA European Affairs 2006, 79) gives the following figures for cultural employment in the EU25 in 2004: Of a total employment of 191.563 million, 4.714 million (2.5%) can be attributed to cultural employment; a further 1.171 million are understood to be 'cultural tourism employment' (which is 15% of the total employment in the tourism industry). Cultural and cultural tourism employment together thus would amount to 5.885 million (3.1%) of the total employment in the EU25.

The study also gives figures for the growth of this employment between 2002 and 2004: Whereas the total employment showed a negative development of -0.04%, cultural employment grew by +0.88%, and cultural and cultural tourism employment together by +1.85%.

According to more recent Eurostat figures for the EU27, in 2005 cultural employment – covering both employment in cultural occupations in the whole economy and any employment in cultural economic activities – accounted for almost five million people or 2.4% of total employment. The proportion of cultural employment ranged from 1.1% in Romania, 1.4% in Portugal and 1.7% in Poland to 3.3% in Finland, 3.5% in Sweden and 3.8% in the Netherlands (Eurostat 2007b).

People working within the cultural field generally have a higher level of education than those employed in the economy as a whole. Nearly half of cultural workers in the EU27 in 2005 had completed the tertiary level of education, i.e., university studies or similar, compared with a quarter of the workforce in general. The highest proportion of cultural workers with tertiary education was found in Estonia (64%) and Belgium (63%), while the lowest were found in Malta (26%) and Portugal (28%).

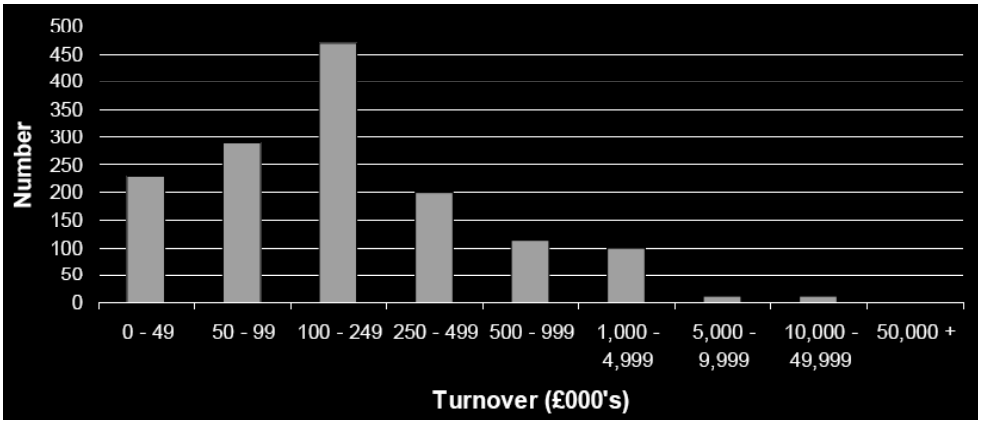
The figures suggest that many educated people understand that the cultural sector provides 'better jobs' (cf. Lisbon Strategy) than other sectors. However, cultural employment is less secure: 16% of cultural workers in the EU27 had temporary jobs compared with 13% for total employment; 29% of cultural workers were non-employees compared with 14% in the total workforce.

Cultural heritage sector businesses and employment – example: UK

Creative & Cultural Skills (2006) commissioned a study on businesses and employment in the UK cultural heritage sector. The study was carried out by TBR Economics and understood CH to comprise museums, built heritage, archaeology, and related membership organizations.

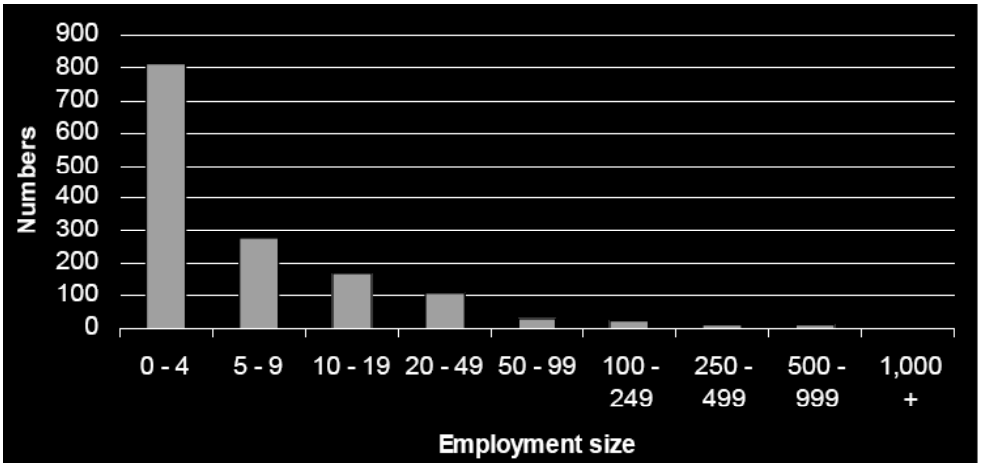
Some interesting results of the study are:

- There are 1,430 businesses in the sector and the total employment is 53,810 persons;
- The distribution of this employment is as follows: Museums account for 59%, built heritage for 28%, archaeology for 13% and membership organizations for 1%;
- The total Gross Value Added of the sector's businesses is £952 million (0.15% of UK GVA), and the average GVA per employee is £17,600. Museums make the most significant contribution at 85%.
- The following diagram shows the distribution of the businesses by turnover size; only 8% have a turnover equal to or more than £1 million:



Source: Creative & Cultural Skills, 2006

- The following diagram shows the distribution of the businesses by employment size; only 13% of businesses employ 20 or more people:



Source: Creative & Cultural Skills, 2006

- 67% are full time employments, 13% are temporary jobs (43% of these are seasonal), and 4% are working in CH as a second job;
- 7% are self-employed, 3% are freelancers (museums account for about two-thirds);
- 95% of the workforce is white, 56% is over 40 years old (around 1 in 5 are under 30), and there is a small majority of female workers (52%);
- 14% of the workforce are disabled according to the DDA (Disability Discrimination Act) and/or have a work-limiting disability.

Cultural heritage employment and wider employment effects

Employment statistics in the cultural heritage sector are not particularly compelling, although the wider employment effects of cultural assets are understood to be considerable.

A study on the economic valorisation of cultural heritage in France (Greffe 2002) estimated the indirect employment effect in the domains of conservation and maintenance, related employment in the tourism sector, and induced employment in other sectors to be as follows:

Direct employment in the CH sector	43,880	8.38%
Indirect employment in conservation and maintenance of CH	41,714	7.97%
CH related employment in the tourism sector	176,800	33.79%
Induced employment in other sectors	260,830	49.85%
Total	**523,224**	

Table 11.1: Direct, indirect and induced employment of cultural heritage in France. Source: développement culturel 2003, based on Greffe 2002

In this context the ratio of direct employment in the CH sector to related employment in the tourism sector is 1:4, and to induced employment in other sectors 1:6. Similar ratios (or 'multiplier effects') are given in a number of other studies. For example, in the UK the National Trust has carried out surveys on the economic impact of their work in maintaining historic properties and promoting tourism in a number of regions. The Trust estimated that it generated between five and nine additional full-time equivalent posts for every job for which it was responsible in the regions studied (English Heritage 2003, 39).

A large part of tangible CH is built infrastructure (e.g., historic houses, monuments, churches and monasteries) that requires conservation and regular maintenance. Besides having a higher multiplier effect and lower carbon footprint than new construction projects (Rypkema 2005, 2006, 2007), the specific demands of heritage infrastructures help retain specialist skill sets. Moreover, there is a shortage in such skills. The UK report 'Valuing our heritage – The case for future investment in the historic environment' notes: "The built heritage sector has a workforce of 86,430 but needs an extra 6,590 craftspeople to resolve skill shortages and meet demand" (English Heritage 2005a; Valuing Our Heritage 2007, 15).

In this context it is worth noting that cultural heritage in general is labour-intensive and jobs in this sector are very unlikely to be transferred to other parts of the world.

11.2.2 Cultural heritage and the tourism industry

Importance of the tourism sector for growth and employment

Tourism is one of the most important sectors of the European economy. Depending on the definition of the tourism sector, its contribution to the Gross Domestic Product (GDP) of the European Union varies between 4% (tourism industry) and about 11% (tourism economy). Correspondingly, the number of people employed ranges from 7.3 to 20.6 million, respectively, representing about 4% and 12% of total employment. In 2004, the EU25 had 403,463 tourist accommodation establishments with 24.42 million bed places to fill. Hotels and similar establishments (201,021) alone had a work-force of 7.831 million. The overall tourism sector shows an annual growth rate of about 3% and creates some 100,000 new jobs per year. (EC 2004b; Eurostat 2007a)

According to estimates of the Study on the Economy of Culture in Europe (KEA European Affairs 2006, 76), 15% or 1.171 million jobs in the tourism industry can be understood as 'cultural tourism employment' (calculated from a larger base figure of the tourism industry than the one given above).

Richness in culture and cultural heritage as a major tourism attractor

Europe is the region most visited by international tourists. In its Tourism Highlights Edition 2007 the World Tourism Organization reports for the year 2006 international tourist arrivals in Europe of 460.8 million, which is a share of 54.4% of the world market of 846 million. The worldwide international tourism receipts, excluding international passenger transport, amounted to 584 billion, of which Europe earned 298.3 billion (51.1%) (WTO 2007b). It may also be of interest to note that 88% of European outbound trips are for destinations in Europe (Leidner 2007).

The most important motivation of international tourists was 'leisure, recreation and holidays' (51%), business travel accounted for some 16%, and 27% represented travel for other purposes, such as visiting friends and relatives, religious reasons/pilgrimages, health treatment, etc. (the purpose of visit for the remaining 6% was not specified) (WTO 2007b).

One major factor for the attractiveness of Europe certainly is the cultural richness of its countries. For example, Europe has more cultural sites inscribed on the UNESCO World Heritage List than any other part of the world, with over 300 entries of cultural and natural significance. The inscription often carries with it increased publicity and a sense of prestige and status; UNESCO estimates that increased tourist visitation of 40–60% is not uncommon within two to three years of inscription of a site on the World Heritage List.

In fact, Europe's patrimony is an important asset in economic terms, and cultural tourism is good business, especially also in the new EU Member States. For example, a quarter of Cyprus' GDP comes from tourism. Even in industrial countries like France and Germany, tourism accounts for 7% and 8% of GDP respectively (cf. EC 2004c, 5).

Cultural and natural heritage tourism is one of the fastest growing segments of the tourism business. Roughly 30% of European tourist destinations are chosen by virtue of the presence of heritage sites. This number increases up to 45–50% if the wider cultural sector such as important festivals and other cultural events are included (Linty 2005).

According to the Eurobarometer survey 'Europeans on Holiday' 1997/98, 'historic interest' was the fifth most common reason for the choice of tourist destination (by 32% of those surveyed), coming after (1) 'scenery' (49%), (2) 'climate' (45%), (3) 'cost of travel' (35%), and (4) 'cost of accommodation' (33%) (Eurobarometer 1998). The citation of scenery here may also have a cultural heritage component. Looking at this list access and condition of cultural heritage is perhaps the influence most susceptible to active management by national and regional authorities, making cultural heritage an extremely important component of any strategic plan to benefit from potential tourism revenues.

It should also be noted that for most cultural sites domestic visitors will be far more important than foreign tourists:

> "An important point to make about cultural tourism is that not all visitors to cultural sites are tourists. About 36% of the 2002 ATLAS survey respondents lived in the local area. Less than one third were foreign tourists. This emphasizes the point that apart from a select few sites or events where the majority of visitors come from abroad, the domestic market is of vital importance for most cultural tourism attractions" (ATLAS – Association for Tourism and Leisure Education 2002).

Figure 11.2: Mosaic at Fishbourne – Fishbourne Roman Palace, UK

Major cultural events as tourism drivers

The importance of major events for regional economies should not be overlooked. The most important 'event' in Europe is certainly the European Capitals of Culture (ECOC) initiative that was launched in 1985 with the aim of highlighting the richness and diversity of European cultures and to promote greater mutual acquaintance between European citizens. An evaluation of the years 1995–2004 (29 ECOCs) has been carried out by Palmer-Rae Associates (2004), who particularly looked at the long-term effects of the cities' investments.

With respect to tourism impact the only reliable figure for comparisons was overnight stays in the host cities up to 2003. The average increase of overnight stays compared with the previous year was 12%, though, with considerable variation ranging from +23% in one city to -6.7% in another. The impact of the ECOC seemed to result in a higher tourist flow at least one year after the event, although most cities experienced a decline in tourist numbers in the years after.

One of the lessons learned by ECOCs is that it is a good investment to convert old buildings into museums, galleries, libraries or venues for the performing arts. For example, Pécs (Hungary) will be a Capital of Culture in 2010 and the largest among several development projects in this context is to create a cultural quarter on the premises of the Zsolnay porcelain factory; the estimated investment for developing this industrial heritage site into a cultural quarter is €43.6 million (Hegyi 2007).

Some European cities focus particularly on festivals and other large events to strengthen their visibility and attract cultural tourists. Among the outstanding examples is Edinburgh: In 2004 the five international summer festivals had 2.6 million visitors and, generated some £127 million of expenditure for the Edinburgh economy, which supported about 2,500 full-time equivalent jobs (City of Edinburgh Council 2005). Their largest event, the Edinburgh International Festival, had a geographical spread of visitors of "39% from Edinburgh, 23% from the rest of Scotland, 24% from the rest of Britain and 14% from overseas. Sixty-two percent of the visitors interviewed said that attending the festival was their only reason for visiting Edinburgh, with a further 26% saying it was very or fairly important." (EIF Society 2006; for analysis of the competitive position and economic impact of the Edinburgh festivals see SQW Limited and TNS Travel and Tourism 2005, and AEA Consulting 2006)

The regional importance of an established festival will be felt most if things go wrong. This was the case in 2003 with the renowned theatre festival in Avignon and other festivals that had to be cancelled. This was because of strikes and protests by the artists and technicians in the performing arts and audio-visual industry against planned changes in their unemployment insurance. Avignon has a population of about 120,000 and the festival is the primary tourist magnet in the summer season, drawing 700,000 people annually. The festival normally receives a combined public subsidy of €4 million (60% national government, 20% City of Avignon, and 20% regional funds) and is estimated to have a regional economic impact of over €30 million. In 2003, the cancellation of the festival resulted in a loss of about €22 million. (cf. Archambault and Baudriller 2005; Klaic 2006; Picard and Passariello 2003)

11.2.3 The social role of culture and cultural heritage in urban and regional revitalization

The Lisbon Strategy includes the goal to make the regions and cities of Europe more attractive places to work, live and invest. Though usually not the primary reason for business and residential location, culture and cultural heritage are understood to be crucial for the specific character, identity and image of regions and towns and an important element of the quality of life of the residents. Moreover a dynamic cultural sector will strengthen the economic environment through bridging global trends and local skills and retaining and attracting creative people.

Availability of creative people is a prerequisite for a competitive and innovative region. There are clear correlations between the vibrancy, quality and diversity of the cultural life of urban areas and the presence of knowledge-intensive and creative businesses. Indeed, in areas where highly skilled and creative people want to live such businesses can be established more easily. (cf. Florida 2002; Ray and Anderson 2000) However, urban centres must create the right environment for such development, which, besides appropriate housing and office space, also requires a broad range of opportunities for cultural participation.

Social roles of cultural and creative clusters

Strategies of 're-inventing' and revitalizing a region or town include programmes for attracting new businesses and creating job opportunities, refurbishment and new usage of former industrial production facilities and storehouses, revitalisation of retail streets, squares and parks, creation of community and cultural centres, and the organization of commercial, cultural or sporting events.

The role of cultural activities and creative industries as driving forces for urban regeneration has been a particular focus of the URBACT Culture project. Reports written by the thematic experts Jean Hurstel (social dimension), Charles Landry (city [re-]development), Jordi Pascual (physical dimension) and Paul Rutten (economic perspective) provide excellent summarization of knowledge and good practice in these fields (Hurstel 2006; Landry 2006; Pascual 2006; Rutten 2006).

Often urban regeneration strategies have been inspired by the concept of cultural or creative clusters. Such clusters seek to pool and stimulate synergies between a variety of creative resources such as media centres, arts venues, cultural institutions, non-profit cultural enterprises and individual artists (Mommaas 2004; Santagata 2006). Furthermore, flexible, multi-purpose cultural infrastructures are created that serve as 'creative hubs' by providing space and facilities to meet, work, acquire skills, network and form partnerships. One example of such an infrastructure is the Watershed in Bristol (UK) that was established in a disused dockside warehouse (Watershed Case Study 2006).

Commercial initiatives of cultural or creative clusters seek to promote the development of businesses in industries such as media, software, music, visual arts, architecture, design, fashion, etc. Yet, companies that emerge from such initiatives are typically small (on the average only 3–5 employees per company) or micro-businesses of self-employed or freelance workers (cf. Wiesand and Söndermann 2005). Examples and lessons learned from creative industries development projects can be found in the handbooks of the International Conferences on Creative Industries Development 2004-2006 (http://www.creativeclusters.com).

Also, the many positive social effects of investments in cultural assets and creative businesses must be taken into account:

– They promote a professionally stimulating urban environment where people are exposed to new ideas, cultural expressions, and informal networks.
– They have particular aesthetic and symbolic values that provide the ideal environment for street life, fashionable cafés and restaurants, events, night life, etc.
– Even more importantly, they add to the overall tolerance of a town of different values and attitudes and preferences concerning diversity, openness and self-expression. 'Tolerance' has been identified by Richard Florida in his seminal work *The Rise of the Creative Class…* (Florida 2002) as important for a region's creative edge as 'technology' and 'talent'.

Many regional and municipal decision makers today have understood the positive impact culture and revitalized historic assets, cultural production, and events such as festivals can have on the image of the region or town as well as in reshaping social life (e.g., through changes in the social stratification). Consequently towns not only invest in the infrastructure for cultural life (e.g., museums, places for performing arts, etc.), but tend to support cultural projects more actively. For towns with a poor (or no) image this can be crucial.

Culture and cultural heritage in the revitalization of post-industrial towns

The importance of a rich cultural life is felt most if it is missing. For example, when an urban area, a city quarter or a whole town have become run down as is often the case with "post-industrial" towns that experience a crisis because of deindustrialization. Many such towns have chosen to use cultural creativity for weaving new narratives of regeneration and growth (cf. Bramwell and Rawding 1996; Hall 1995; Trueman and Cornelius 2006).

While the motivation is to increase through positive images of a dynamic culture and rich cultural heritage the attractiveness of the town for businesses and talented people, culture and cultural heritage-led revitalisation can serve the equally important functions of:

- leveraging the confidence of local stakeholders in the town's future,
– fostering creativity and entrepreneurship within local communities, and
– enhancing people's self esteem, local pride and sense of belonging.
– It is vital for towns and regions to have a good understanding of the cultural and heritage assets and how they can be effectively used in revitalization strategies. In particular, for such regeneration projects it is crucial to instil a sense of collective ownership and responsibility among people by involving local communities.
– The important role of the cultural element in the revitalization of urban areas is widely acknowledged today by urban planning experts, researchers and practitioners (cf. Brault 2005). For example, in the report *The Contribution of Culture to Regeneration in the UK: A Review of Evidence* a municipal official is cited saying:

– "My own blunt evaluation of regeneration programs that don't have a cultural component is that they won't work. Communities have to be energized, they have to be given some hope, they have to have the creative spirit released" (Evans and Shaw 2004, 3).
– A widely used approach of energizing local communities has been small-scale, participatory culture and arts projects. The credentials of such projects as a tool for social renewal have often been exaggerated in that considerable impacts such as enhanced social cohesion or organizational capacity, sustained public/private sector partnerships, reduced crime and offensive behaviour, etc. were claimed. However, little solid empirical evidence to support such impacts is available (cf. Selwood 2002). Particularly with respect to social inclusion through cultural projects it has been found "that rhetoric, practice and evidence gathering are only rarely heading in the same direction" (QUEST, 2002, 2).

11.2.4 Cultural heritage within integrated strategies for attractive regions and towns: Guidance for heritage-led regeneration

In the above sections it is argued that Europe benefits considerably from its richness in tangible and other heritage assets. Securing and exploiting this potential will require that historic towns and heritage sites have a firm place and are systematically considered within national and regional socio-economic frameworks and regeneration programmes (cf. Leipzig Charter on Sustainable European Cities, 24 May 2007).

The INHERIT – Investing in Heritage to Regenerate Heritage Cities – project, co-funded under the INTERREG IIIC programme, has produced a major guidance report on heritage-led regeneration, *Investing in Regeneration. A Guide to Successful Urban Heritage* (INHERIT 2008). The INHERIT network has been led by the EPOCH consortium partner European Association of Historic Towns and Regions (EAHTR) based in Norwich and involved the city councils of Newcastle upon Tyne, Göteborg, Verona, Gdansk and Ubeda and the Queens University Belfast.

INHERIT nourishes an integrated approach of increasing the capability of towns and cities to regenerate physically, economically and socially by investing in their tangible heritage. With kind permission of the project coordinator European Association of Historic Towns and Regions we reproduce in the information box below the high-level recommendations of the INHERIT guidance report.

INHERIT recommendations for heritage-led regeneration of historic towns

Think Strategically...

1. Value investing in heritage as key to urban regeneration and sustainability.
2. Understand 'identity of place' and integrate heritage into corporate strategy
3. Recognize the importance of leadership, aspiration and a holistic approach with appropriate organizational structures
4. Monitor results and quantify environmental, social and economic benefits
5. Link benefits with the 'Lisbon' and 'Göteborg' agendas – job creation and sustainability
6. Ensure specialist skills and capacity are available and facilitate training

Focus on Identity and Diversity...

1. Prepare 'audit' to understand context and define character and identity
2. Recognise the contribution that 'common heritage' can make to character
3. Understand the social value of 'identity' to local people and its appeal to visitors
4. Encourage 'diversity' as means of spreading activities and ensure new uses for old buildings are sustainable
5. Develop cultural approaches that relate to people as well as buildings and include recent events as focus for cultural tourism
6. Value 'quality' in terms of design and materials and welcome good contemporary design

Invest in Regeneration – especially the Public Realm...

1. Use public sector investment as catalyst for wider regeneration – especially in the public realm
2. Balance accessibility with enhanced space for pedestrians, cyclists and the reduction of pollution
3. Improve surfaces using natural and other quality materials, enhance lighting, signage and interpretation and consider modernising infrastructure
4. Link public realm improvements to opportunities for cultural events

Work in Partnership...

1. Recognise the respective roles of the public, private and community sectors
2. Work with the private sector and consider new approaches to funding and delivering public benefit
3. Involve the community and key stakeholders in decision making
4. Understand the value of community engagement in building people's sense of 'ownership' and 'pride of place'
5. Encourage community and stakeholder 'champions' to promote the benefits of investing in heritage

Source: INHERIT leaflet 'Investing in Heritage. A Guide to Successful Regeneration', 2007. Note: In the final report the above recommendations are presented in more detail. URL: http://www.inheritproject.net

11.3 Appreciation of common and diverse cultural heritage

Culture encompasses contemporary cultural values, practices and aspirations of communities and individuals as well as the cultural heritage that has survived from the past. There is no cultural heritage *per se*; what counts and survives as cultural heritage is an outcome of a valuation and selection process which is motivated by political and social interests, perspectives of academic disciplines and professions (e.g., the arts and humanities) as well as market mechanisms. Today, we observe profound changes in the notions of 'culture' and 'heritage', and cultural diversity has become a core paradigm of cultural heritage policy.

11.3.1 Changes in the notions of 'culture' and 'heritage'

In the last 20 years or so there has been a tendency towards an inflationary use of the label 'heritage'. David Lowenthal has offered perhaps the most thoughtful critique of this development, observing 'all at once, heritage is everywhere – in the news, in the movies, in the marketplace – in everything from galaxies to genes. It is the chief focus of patriotism and a prime lure of tourism. One can barely move without bumping into a heritage site" (Lowenthal 1998, xiii).

Museum doyen Kenneth Hudson has observed this development with respect to industrial heritage, which has become a field of interest only since the 1960s. Hudson writes:

> "Until the 1960s, there were only derelict factories, old railway stations and disused canals and few people took the slightest interest in them. And then the term 'industrial archaeology' was invented. Almost overnight this mass of crumbling buildings and rusting machines became important historical material, deserving preservation and careful study. A new academic discipline came into being. A label had made people notice and value what had previously been regarded as eyesores and junk" (Hudson 1996).

As this example may illustrate particularly well, labelling something as heritage, and wanting to preserve it for whatever purpose, will require an investment on the side of the private owner or/and the community. Indeed, whether there is 'a future for the past' (Peacock 1994, 1998) depends on the level of appreciation of societies of historical and cultural knowledge and the historical environment, monuments, sites, and heritage objects that are held and presented by physical museums, archives and libraries, and increasingly in the digital space.

There is not only a growing 'abundance' of heritage, in the last decades the meaning of 'culture' in general has undergone a severe change. As Paul Streeten from the World Development Institute writes:

> "More than thirty years ago 'culture' stood for the *values* we thought all of humanity shared. Today it has come to mean almost the opposite: what every little group, regional, sexual, ethnic, religious, differentiates from others, asserts its identity. The transition from 'Culture' to many cultures or from a global culture to many minicultures has meant a change from universal humanity to the diversity of subcultures, every one often highly antagonistic and hostile to others" (Streeten 2000, 40).

Streeten rightly points to increasing cultural contradictions within modern societies. However, they may be somewhat less critical than suggested, at least within the European Union, as can be concluded from the results of a recent Eurobarometer survey on people's attitudes to culture. The study was carried out in February/March 2007 by TNS Opinion & Social, interviewing 26,755 persons from all over Europe (EU27) and from all walks of life. The main findings of the survey include (cf. Eurobarometer 2007; Europa.eu 2007):

- 76% of the respondents consider that Europe's cultural diversity is the defining characteristic of Europe, and that this diversity actually helps to increase the impact of European culture;
- 67% of Europeans consider that when compared with other continents, the European countries have a lot of cultural aspects in common;
- 58% of respondents were positive about the effects of globalization on European culture, saying that it will give new dynamism to European culture, thereby extending the influence of Europe in the world.

A very large proportion (88%) feel that cultural exchanges are important, and they call on the European Union to facilitate cultural exchanges for Europeans, and so promote intercultural dialogue. For the European Commission, these survey results give clear support for its recent Communication *A European agenda for culture in a globalizing world* (10 May 2007) (EC 2007b).

11.3.2 Diversity as paradigm of cultural heritage policy

In 1988 the United Nations, along with UNESCO, established the 'World Decade for Cultural Development', an initiative that stemmed from a perceived loss of cultural diversity on the one hand, and the rise of religious and ethnic fundamentalism on the other. Major publications, such as the report *Our Creative Diversity* from the World Commission for Culture and Development (1996) and *In from the Margins* from the Council of Europe, Culture Committee (1997) pointed to the centrality of culture to development on the global as well as on the local level.

The key idea of *Our Creative Diversity* is understood to be contained in the two opening sentences of the executive summary of the report: "Development divorced from its human or cultural context is growth without a soul. Economic development in its full flowering is part of a people's culture." Importantly, this is different from seeing culture as either a help or a hindrance to economic development, leading to the call to take cultural factors into account, awarding it a constructive, constitutive and creative role.

Also, at the same time, and ever since, sociologists and political scientists have observed an increasing worldwide clash of cultures in the post-Cold War world brought about by the process of globalization, in particular of media and telecommunications that bridge the local and global (Barber 1996; Inda and Rosaldo 2002; Jameson and Miyoshi 1998). However, different cultures must embrace the clash and struggle for mutual understanding, respect and appreciation of each others' culture. If this is not done the result is cultural ignorance, 'ghettoization' and sterility. In other words, with the clash can come cross-cultural inspiration and an appreciation of the richness of cultures worldwide.

The role that responsible cultural tourism can play in the development of cross-cultural dialogue should be particularly acknowledged (cf. Robinson and Picard 2006, with reference to UNESCO's many activities at the cross-section of culture, tourism and sustainable development).

11.3.3 Promotion of the diversity of cultural expressions and heritage interpretations

The UNESCO Convention on the 'Protection and Promotion of the Diversity of Cultural Expressions' (UNESCO 2005) reconfirms that cultural diversity and dialogue among cultures are major cornerstones for a global order based on peace, mutual understanding and respect for shared values. Yet, what often works well in contemporary cultural expressions (in particular, music) is more difficult to achieve with cultural heritage. Heritage is related to the cultural identity of people that share a common history, a territory in which they live (or their ancestors have lived), symbols and traditions that are cherished, etc. Furthermore, the presence of many different ethnic and religious groups as well as sub-cultures within a society pose the question of how their cultural and artistic expressions can be included in appropriate ways by cultural heritage institutions.

This requires a very conscious interpretation and communication of heritage values which should involve members of the cultural heritage community. The current practices of interpreting and communicating cultural heritage have been established by disciplines and professions related to memory institution such as museums, who have acquired a mandate and legitimization to define, evaluate and interpret cultural heritage resources. Yet, today there are many communities, groups and individuals that demand to be involved in the presentation and (re-) interpretation of a society's historical record and memory, and cultural heritage institutions are challenged to open up to 'non-expert' contextualization of resources and diverse and often conflicting explanations and narratives.

One approach to this can be to develop Web-based environments that allow for 'user-created content', i.e., own heritage documentation and interpretation, and contributions to collections and exhibitions. Current attempts show a very low level of 'opening up' to voices of heritage communities. An illustrative example is the 'Moving here' project that has created a huge online resource on different 'immigration communities' (Moving here [UK

Public Records Office] Web site; Geser and Wood 2004). Here a template for uploading a text and own images (or attaching material from the project database) is offered and the content is checked for possibly offensive statements or visuals. 'Social software' tools would allow for more open approaches, which, however, must be implemented with great care (see section 8.4, 'Social software' applications and user-created content).

11.4 Basic issues in a socio-economic research agenda for CH and ICT

In the following sections we identify some basic issues in a socio-economic research agenda for cultural heritage and ICT. For the most part these issues pertain to appropriate models and empirical data for policy making and decisions on investment in the preservation and promotion of cultural heritage, adoption of ICT applications in the heritage sector, institutional capacity building, etc.

11.4.1 Evidence for investment in tangible cultural heritage preservation and development

While the socio-economic relevance of cultural heritage sites for regions and towns is often emphasized, there seems to be a lack of convincing, empirically-based arguments for investing in cultural heritage preservation, promotion and valorization. Indeed, providing an investment perspective is often difficult. For example, the Operational Programme of the European Territorial Cooperation 2007–2013 for Central Europe states:

> "In general, the richness of the cultural heritage in the programme region is endangered since the investment perspective is lacking for large parts of the heritage. Efforts regarding the restoration and revitalization of cultural sites concentrate on those areas, where the economic perspective including the positive impact on employment (especially for women) is clearly visible. Compared to the programme region as a whole, the number and size of these zones is limited" (European Territorial Cooperation 2007–2014, 16).

However, the business case for investing in cultural heritage is also not easily found for many projects where less is at stake than in many parts of Central Europe. For example, how much would an additional restored historic building add to the heritage value of a town? What is the added value of a museum Web site, or of digital presentation displays in the visitor centre of an archaeological site?

It would be much easier to compete for scarce funding resources if cultural heritage managers could point out the enhanced socio-economic relevance of an intended project (e.g., based on evidence from similar investments). Socio-economic relevance is understood as the social and economic benefits of the activities of a CH institution: The social benefits consist of what people gain from exhibitions and cultural learning programmes. This can include a greater understanding of the history of a region, reflection of the diversity of cultural expressions, intellectual and creative inspiration, etc. The direct economic benefits comprise the income generated by the institution (e.g., from ticket sales, museum shops, providing room for receptions, seminars, PR events, etc.) as well as by businesses in the region (e.g., from tourist and other spending).

The Outspan Group notes:

> "In the past, whenever economic arguments were used by cultural/heritage institutions in support of their programs, the main thrust centred on the economic impacts or spin-off effects related to the spending by the institution and its visitors. Although it can be viewed as better than no economic argument at all, this approach was never very successful or persuasive with funding organizations. One of the troubles with the economic impact argument was that most of the economic impacts were not economic benefits. (…) Within the cultural/heritage community, there developed a belief that economic analysis could not support the needs of organizations and, in fact, could lead to the undermining of institutions. This was largely true considering the way economic impact analysis was used" (Outspan Economic Consulting Group 2001).

Cultural heritage institutions do not preserve and make sites and objects accessible to the public primarily for economic reasons. Hence, pointing out also the economic benefits of the institutions' activities should not replace the appreciation of their cultural and scholarly work, but help give a clearer picture of CH sites' overall significance. Developing a much better understanding of this significance, indeed, demonstrating 'good value for money', could have a considerable impact on heritage policies, public funding, private investment and public–private partnerships.

Related to this is also the question of how costs of restoration, development and maintenance should be shared between public and private sector investors. For example, operators in the tourism sector often see heritage resources as available 'for free'. Indeed, as Gregory Ashworth writes, there are

> "…attitudes of many within the tourism industry who view heritage as a zero-cost, freely accessible public good. Simply heritage costs money for its preservation, continuing maintenance, management and presentation. Heritage tourism is too often seen as a marginal use of already existing resources whose demands can be accommodated without extra cost or the displacement of other users" (Ashworth 2004, 7).

11.4.2 Models of the socio-economic impacts of CH on various levels

It would be helpful to have solid input–output models, indicators and tools available for identifying the socio-economic benefits as well as possible negative effects of CH at the level of a region or a town. Such models also should provide support in drawing out and evaluating alternative regional and urban development strategies.

If we again take as an example the area of tourism, it would be beneficial to have a Tourist Area Life-Cycle model (Butler 2006a, b) specifically for areas that already attract or want to attract tourists mainly based on their cultural heritage assets (e.g., a historic town or a rural area that is mainly visited for a major archaeological site). Such a model should provide indicators for the tourist-carrying capacity of the site, i.e., its ability to absorb certain levels of visitors and related infrastructure before the CH values of the place are diminished to an unacceptable degree (Coccossis et al. 2001). Backed up with survey data, this could provide an early warning system and inform the implementation of measures for establishing limits of use and development that are permitted within a controlled area (cf. EC 2002b; Manente 2004; WTO 2004b).

It has been noted that studies on CH benefits "tend to overestimate the economic impact, since they usually leave out the negative effects of cultural projects (traffic congestion, the loss of economic value due to regulation)" (Klamer and Zuidhof 1999, 33). In fact, reliable socio-economic models of cultural heritage impact need also to help capture possible negative effects. If we take the example of the tourism industry in Venice, it is estimated that tourism pumps one billion euros per year into the Venetian economy. While the expenditure of visitors on cultural products or services is less than 3% of their budget, it seems clear that it is the cultural heritage image that attracts visitors to Venice. But tourism also generates substantial costs to the city because of social changes and environmental externalities such as depopulation, congestion, etc. Should these costs not also be attributed to cultural heritage? Jan van der Borg and Antonio P. Russo suggest:

> "If we accept that culture is what attracts visitors to the city, then we ought to admit that it is also at the basis of the many ills that are making of Venice a wasteland. So, the real economic impacts of culture could be anything from negative to a billion euro a year, depending on the conceptual approach, on the spatial scale involved, on the instruments used" (Borg and Russo 2005, 27; see also Russo 2002).

11.4.3 Leveraging the adoption and impact of ICT in the CH sector

Of particular importance for a wider adoption and greater impact of ICT in the CH sector would be studies that demonstrate to individual sites the benefits of implementing certain ICT applications. In fact, the business case for many applications may not be as clear as claimed by the technology providers.

Unfortunately, there are only few studies available that confirm that visitors are willing to pay for using such applications or, even, use them to a considerable degree if they do not have to pay an extra fee. To date only one non-market study has attempted to value ICT at a cultural heritage site (cf. McLoughlin, Kaminski and Sodagar 2006, 28–42). This study was conducted at the Galleria Borghese museum in Rome, where a survey contained questions about visitors' willingness to pay for additional multimedia services (Mazzanti 2003a, b).

An exploratory visitor survey at five UK heritage sites, museums, monuments and archaeological sites that have implemented different ICT applications concluded that all of the applications "…were found to be underutilized". However, visitors who had been at the site before showed a higher use of applications than those who were on their first visit, e.g., for a computer game this was 4% (first visit) in comparison with 16% (repeat visitors). "This suggests additional uses for technology: to entice the visitor back to the site and to enhance the repeat visit experience by exploring the technology on offer" (Owen, Buhalis and Pletinckx 2005).

These studies suggest that there is too little knowledge available for decision-making on investments in CH ICT applications, and that current approaches of implementing such applications at CH sites may not bring about the expected benefits.

However, there is a potential parallel between the attempts to evaluate return on investment in ICT in the cultural heritage sector and the attempts to quantify investment in other sectors – perhaps most notable the investment in Computer Aided Design (CAD) in the 1970s. Architecture is an interesting comparator domain, dealing in human values, 3D objects and environments, their modelling and visualization. However, there are of course important

differences in the economics of the sectors with architecture involving high capitalization, new materials and 'perfect' shapes in contrast to the Cultural Heritage Sector.

It was noticeable that contemporary attempts to attribute direct economic advantage to the development of CAD systems in sectors such as architectural design usually struggled to find direct payback on investment. The 'easy' arguments of more efficient design completion rarely seemed to be backed by evidence yet it is clear that thirty years later the architectural profession has adopted ICTs in widespread areas of practice and it would be virtually inconceivable for a sustainable architectural practice to ignore the potential of ICT applications in support of design management, visualization etc. The true benefits are significantly different from those that were originally envisaged and are phrased in terms of the ability to be responsive to clients and assistance in designing sound structures with more freedom of form than manual methods might have allowed.

Similar predictions can be made about the likely impact of ICTs on the professions associated with cultural heritage. It is likely that applications of ICTs will significantly alter the day-to-day working practices in these professions and enable whole ranges of previously unknown working practices which meet the strategic objectives of cultural heritage professionals in different ways. It is also likely that this evolution will take 20–30 years as the working practices and professional education of future generations adapt to the new potential. This should not be a surprise – it may well be a property of developing people's ability to adapt to fundamental paradigm shifts. The same processes can be seen as the mature computer games industry (that most 'techy' of new sectors) evolved over perhaps 25–30 years from the initial interactive games to a mature industry sector where the consuming public were familiar with standardized paradigms for computer games usage.

In the cultural heritage sector these developments will continue to require nurture and effort should be expected for some time to come in developing understanding of effective working practices and spreading the education and training required to change the profession's practice.

11.4.4 Education, training and continuing professional development as a key element for cultural heritage valorization

Because of the re-examination of the societal roles and relevance of cultural heritage institutions in today's society, rapid innovations in ICT, and changes in user demands there is a considerable demand in upgraded and new qualifications in the sector. This also is the case in the field of cultural administration (cf. ENCATC – European Network of Cultural Administration Training Centres, www.encatc.org).

Indeed, education, training and continuing professional development is a key element for leveraging the valorization of cultural heritage assets. The required update in competence profiles, for example, comprises knowledge and skills in site management, user demands in services, partnerships with other sector organizations and businesses (e.g., tourism providers, creative businesses), effective deployment of new ICT (e.g., digitization, enhanced online access, onsite interactive installations), and evaluation of social and other impacts. As in other sectors, there is a need for re-training people who already work in CH institutions.

In particular, there is a critical lack of required ICT skills, and the sector simply cannot wait for new generations of computer and IT-literate heritage professionals. There is some guidance available for training and qualification in 'digital culture' to promote job opportunities in cultural and creative businesses (for example, MKW 2001), but only a small part of this will overlap with the generally different objectives and tasks within the cultural heritage sector.

Which particular knowledge and skills are needed for which positions and tasks, and how they could be best provided for, may well be one of the most important research questions in the valorization of cultural heritage.

11.4.5 Need of empirical data for decision making

The issues addressed above should make it clear that there is a considerable demand for empirical data for modelling and validating socio-economic impacts of cultural heritage and, thereby, should allow for well-informed decision-making on cultural heritage policies and development projects at all levels.

For example, the Norwegian Directorate for Cultural Heritage carried out an exploratory study on the role of monuments and historic buildings as economic value generators. They collected figures from heritage authorities and other sources and made some basic calculations. For example, they wanted to establish the 'capitalization factor' of public investments in castles, churches and abbeys. However, they concluded, "…we have some figures but are lacking critical data elements allowing us to make precise calculations based on empirical facts, analyse and fully exploit our findings". They also suggested that in order to improve the situation it could be necessary "to collect all the available empirical data which is presently 'lying around' in national administrations, tourist

institutions and NGO's working with cultural heritage" (Riksantikvaren – Directorate for Cultural Heritage, Norway 2005, 12 and 16).

It also has been noticed that at present data is primarily available on the production and consumption of cultural goods and services that have a market price. But there are also many benefits of culture and cultural heritage assets that cannot be measured easily, yet would be missed if the assets did not exist. For example, the image of a historic town would be damaged if 'brand assets' such as widely known buildings were lost. Similarly, some less known tangible heritage often plays an important role for the cultural identity of the local community. Furthermore, it is important also to acquire data on intangible, living cultural heritage which "…is certainly the domain in which cultural data are lacking mostly and the major work lies ahead" (Bouchenaki 2002, 4).

As addressed in section 8.2.1, the problem of a lack in data is also felt regarding digital cultural heritage, in particular digitized cultural heritage in 3D format.

In recent years, there has been some progress in cultural statistics, which is exemplified, for example, by the Eurostat Pocket Book on Cultural Statistics, published in October 2007 (Eurostat 2007b). The publication presents harmonized data available in Eurostat, UNESCO, Eurobarometer and other sources. This comprises data on cultural employment, enterprises and external trade, and cultural expenditure and participation.

However, the lack of solid data on European cultural heritage is very clear from the fact that the publication, in a chapter on 'contextual data', provides a list of only the European cultural sites on the UNESCO World Heritage List 2007 and the total admissions of the five most visited museums of sixteen European countries. The latter information has been collected by EGMUS, the European Group on Museum Statistics. This group promotes data acquisition based on a common questionnaire; however, at present there are still many holes in their growing database.

Typically the approach taken in most related efforts on the European level are country reports or 'national profiles' covering a number of agreed themes. Examples of this approach are:

- the *Compendium of Cultural Policies and Trends in Europe* (COMPENDIUM) of the Council of Europe and ERICarts, which also contains some information on cultural heritage policies;
- the information system of the European Heritage Network (HEREIN, European-Heritage.net), which collects information on national heritage policies from governmental services in charge of heritage protection;
- also, EPOCH's 'State of the Union' survey 2004/2005 on policies, practices and developments in CH ICT projects is based on the 'country report' approach (Niccolucci, Geser and Varricchio 2006).

The intention often is to amend such country profiles with statistical data and to achieve some comparability, though little has been achieved so far in this field. As HEREIN write on their Web site:

> "European-Heritage.net intends to provide a range of statistics showing the current status and development of heritage initiatives in each country. Comparing data gathered in different contexts using criteria which are not always sufficiently standardized is no easy task, even today. The hope is, however, that as the site develops, so too will the tools, allowing ever more sophisticated comparison."

However, this does not mean that there is a lack of cultural statistical data on the national level (e.g., by SISTAN in Italy, http://www.sistan.beniculturali.it) and, even, in some cases on a regional level (e.g., by the Osservatorio Culturale del Piemonte; Italy, http://www.ocp.piemonte.it). There is even comparative data available for the city level from the Urban Audit, which provides almost 300 statistical indicators for the living conditions in 258 large and medium-size cities within the European Union and the candidate countries. Though among the indicators in the section 'culture and recreation' only two are for heritage, the number of museums and the number of museum visitors per year.

The problem is that in most cases the data is not collected, analysed and presented in a way that allows for decision-making and controlling the outcome of decisions (Schuster 2002). In fact, there seems to be little demand for such data because of a lack in strategic policy making in the cultural and cultural heritage sector, i.e., attempts to bring about changes in the practices of publicly-funded institutions.

One particularly notable exception is the UK, where the Department for Culture, Media and Sport (DCMS), in line with the overall policy of the Labour Party government since 1997, has asked cultural institutions to increase and broaden the social impact of their activities. Consequently, today the performance indicators, statistical data and reporting available on the sector in the UK represent best practice that is seldom met by other countries (cf. the DCMS annual reports and the many other reports prepared by leading organizations such as English Heritage, Museums, Libraries & Archives, and others).

11.5 Concepts, methods and tools for capturing and analysing the socio-economic impact of cultural heritage

The figures presented in previous sections on employment in the domains of tangible cultural heritage are not particularly compelling. For example, in the UK according to the figures of Creative & Cultural Skills (2006) 1,430 organizations provide employment for 53,810 people, and the Gross Value Added (GVA) of the sector's businesses is 0.15% of the total UK GVA. An estimated 1.171 million in 'cultural tourism employment' in Europe (EU25), which is 15% of the total employment in the tourism industry and 0.6% of the total employment (KEA European Affairs 2006), may be more impressive and add to the appreciation of the rich and diverse cultural assets of Europe in socio-economic terms.

Indeed, cultural heritage organizations today often need to resort to calculations of induced employment in the tourism sector to present their case. For example, the initiative Monuments-en-danger in France argues that monuments in public and private ownership offer an estimated direct employment of 45,000, an indirect employment in conservation and maintenance of 10,000, and an induced employment in the tourism sector of 120,000 (Monuments-en-danger.fr 2007, based on estimates of the Groupement Francais des Entreprises de Restauration de Monuments Historiques and La Demeure Historique – L'association des monuments historique privés).

Public appreciation of historic sites and buildings

CH organizations can also point to the appreciation of historic sites and buildings by most citizens. For example, the 'Taking Part' survey conducted by the UK Department for Culture, Media and Sport (DCMS 2007b) found:

- Over 90% of adults living in England think that when improving local places it is worth saving their historic features;
- Over 70% of people say they are interested in the history of the place where they live;
- Almost 70% of people visit historic sites at least once a year; about 15% at least once a month.

Another survey in Germany by the Institut für Demoskopie Allensbach for VIVACON, a leading investor in the revitalization of historic buildings, found (Goldmann 2006; VIVACON 2006):

– 88% of the 2000 surveyed Germans prefer conservation of historic houses to building new ones;
– 65.9% understand living in a protected building to be 'something special';
– 61% see it as preserving a piece of the history of the town;
– it was also found that the highest interest in renting or buying a protected building is to be found among 20–44 years olds (49%).

Citizens not only appreciate heritage value, they are also willing to invest their own money in heritage. A survey by Arts & Business in the UK found that the heritage domain is the most successful of the non-profit cultural domains in raising money from individuals. Heritage in the survey was defined as the historic built environment, including conservation areas, cathedrals and churches, archaeology, historic buildings and ancient monuments. Heritage organizations in 2004/5 received 72% or £158 million from the total amount of the identified individual giving to the non-profit cultural sector. In comparison, corporations only gave £ 3.47 million and private trusts and foundations played a minor role in funding heritage organizations. The individual giving to such organizations is mainly based on Friends' Schemes (79% goes to heritage organizations) and legacies (85% to heritage) (Arts & Business 2006).

As the figures presented above show, heritage value receives a high level of appreciation. Indeed, it is crucial to preserve and communicate this value in order to sustain and enhance the socio-economic impact of cultural heritage. The following sections will address some important concepts, tools, and issues in the analysis of this impact.

11.5.1 Heritage value and economic categories of value

It is important to have a good understanding of the heritage value of a place or object, because this value is the major reason underlying its conservation as well as the basis for its economic value.

Heritage value

The heritage value of a place or building lies in its cultural significance, which usually is a combination of historical, symbolic, spiritual, aesthetic and social values (cf. Sable and Kling 2001; Throsby 2000, 2001, 84–85):

– *historical value:* the historical character and content provide connection with the past and a sense of continuity;
– *symbolic value:* the symbolic meaning and power of certain places and objects adds to people's cultural identity;
– *spiritual value:* the place or object may promote insights in the meaning of religious, sacred and transcendental practices and experiences;
– *aesthetic value:* the aesthetic quality of the cultural object often is an important element for its enjoyment and may inspire new artistic creativity;
– *social value:* the place facilitates connection with others and the shared social experience (e.g., 'pride of place') can help promote local values and social cohesion.

Because of this multitude of values, cultural heritage places, buildings and other objects can enhance the cultural and social capital and community welfare in a number of ways. The concept of heritage value, though, does not include categories of economic value.

Economic categories of value

From the economic point of view, the value of a cultural heritage asset lies in the benefits that can be derived from its direct and indirect use and, even, non-use. In an assessment of the total economic value or contribution to welfare by a heritage place, building or other object these different values should be acknowledged (cf. Allen Consulting Group 2005; Serageldin 1999).

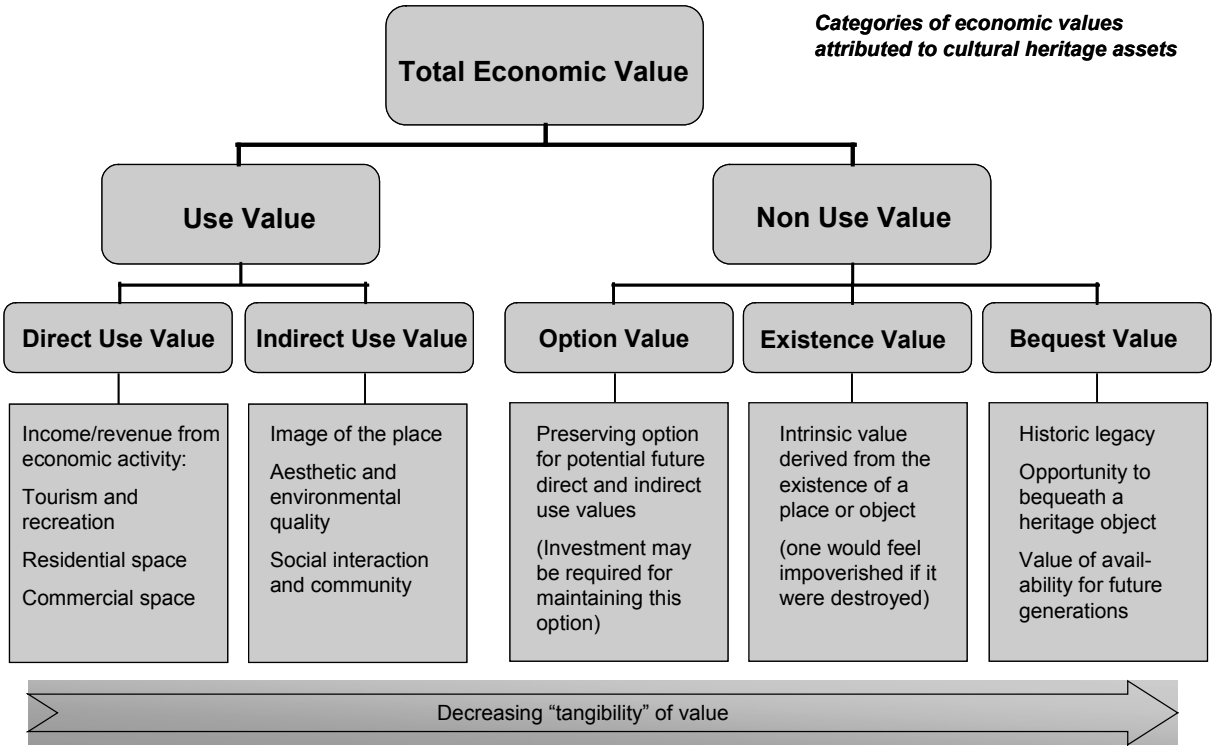


Figure 11.3: Overview of categories of economic values attributed to cultural heritage assets

Brief explanation:
– *Direct use value:* This category comprises the direct economic benefits that can be derived from a heritage site or building, for example, revenues from fees visitors pay to enter the site or the money paid for renting the building as a residential or commercial space; in the latter case the historic character, architectural distinctiveness, etc. has the potential to increase the rent as people enjoy and gain much value (e.g., prestige) from living and working in it (on figures for 'property premium' see English Heritage 2003, 40–41).

– *Indirect use value:* This comprises various societal benefits of a heritage site or building such as its contribution to a positive image of a region, an aesthetically appealing environment, a community's 'pride of place' and sense of belonging.
– *Non-use values:* A heritage site or building also has non-use values, which is shown by the fact that people value having the option to visit it or just its very existence, i.e., they would feel a loss if it were destroyed. People also derive value from having the opportunity to bequeath a heritage object to future generations.

While market prices for direct use values of a heritage site or building can be captured comparatively easily, indirect use values are difficult to evaluate as they have the characteristics of 'common goods', i.e., they are non-exclusive and, hence, not marketable.

Non-use values are often strong motivators of people's willingness to invest (e.g., as tax payers, donors) in the conservation of a heritage place or object. Indeed, they may even be more important motivators than other values. For example, a survey by the Allen Consulting Group (2005) asked adult Australians to agree or disagree with a series of statements to identify people's views on heritage-related values (online survey with 2024 respondents): 93.4% agreed with the statement 'It is important to protect heritage places even though I may never visit them', while only 56.1% agreed that 'Looking after heritage is important in creating jobs and boosting the economy'; 11% disagreed and 32.9% neither agreed or disagreed with the latter statement. These results suggest that people are particularly unclear about the question of whether CH is a relevant area of job creation and economic development.

11.5.2 Economic impact of a cultural heritage site

Regarding the impact of a cultural heritage site on the local/regional economy, the focus is on the various expenditures that originate from the 'direct use value' (see above) of the site. Based on an input–output model the effects of the money spent within the local/regional economy by the site and non-resident visitors, and re-spent by businesses and individuals in the economy, are traced.

Total economic impact and regional capture rate

The total economic impact comprises direct, indirect and induced economic effects, though not all may be accrued by the local/regional economy:
– *Direct effects:* Expenditures by the heritage site (e.g., from external funding) and non-resident visitors for goods and services of businesses in the area bring money into the local/regional economy that would not be available if the site did not exist.
– *Indirect effects:* Increased expenditures made by the businesses that received the initial money (e.g., construction and maintenance companies, shops, restaurants, hotels, etc.) on goods and services of various suppliers from the local/regional economy.
– *Induced effects:* Increased expenditures in the area of the households of the employees and other people who work for the local/regional businesses including the heritage site.

The percentage of the total economic impact of the site that is retained in the local/regional economy ('capture rate') is of particular interest. The higher the percentage, the more self-sufficient the local/regional economy is, i.e., if the goods and services that are consumed are produced wholly or substantially by this economy. The heritage site and other stakeholders would be well advised to follow a conscious strategy of sourcing goods and services based on an 'onion model'. This means that, if available, they are bought first from businesses in the local community, second in the region, third in contiguous regions and fourth elsewhere.

As the motivation of visitors to come to the area is to some degree – in many cases mainly – to visit the cultural heritage site, there is the question to what extent the site benefits from the money that flows to the tourism and other businesses in the area. A site usually captures only 6 to 10% of the total spending in the area (Riksantikvaren 2005, 4). Most cultural heritage sites will not be economically sustainable from this income alone. For example, sites and monuments that receive less than 100,000 visits per year will find it difficult to cover their costs, even if in addition to entrance fees they have some income from shop sales, offering room for receptions, etc. (cf. développement culturel 2003). Hence, there will often be a need to leverage the financial return to the site to ensure its long-term sustainability (e.g., an appropriate flow-back from taxes as public subsidies or financial support by the main beneficiaries).

Policies for ensuring a fair sharing of benefits from well-preserved and managed heritage sites

There is also the issue that some heritage sites are dominated by tour operators, shop owners, etc. from outside the host community, which means that there is a high leakage of revenues that are not reinvested in the local/regional economy. Hence, policies need to be put in place that providers of goods and services from the host community benefit from the public investment in the site and that the public authorities and local businesses have negotiation power vis-à-vis tour operators.

Certainly, a situation where the host community bears the costs of developing and maintaining a site and related infrastructure and services (including roads, water supply, electricity, sanitation, waste collection and disposal, security, etc.) and others reap most of the benefits would not be acceptable as well as not sustainable.

It must be noted that the primarily profit-driven tourism industry and the institutions who manage CH sites are in many ways separate and distinct domains. In particular, the institutions' mandate and mission is to preserve the sites and promote cultural education and scholarly research whereas nourishing good relations with the tourism industry may not be considered by them to be of high importance. For example, the extent to which a heritage site can attract and keep tourists in an area for a longer period of time will usually be more relevant to the tourism industry than to the heritage institution that manages it. This does not mean that tourists are unimportant to heritage sites, because they often represent a considerable proportion of the visitors. Rather the reason is that tourists usually are not the primary reason and focus of the cultural heritage work, and may even be seen as detracting a from CH institution's delivering its core functions.

But due to the economic multiplier effect a well-preserved and attractive heritage site can benefit a whole region. Therefore often tradeoffs regarding the preservation and use level for tourism and other commercial purposes will be necessary. Careful planning and management may reduce the extent of such trade-offs, but usually they cannot be entirely eliminated. The commercial use of the heritage place may generate increased income and employment, but at the cost of some degree of physical degradation as well as impacts on the social carrying capacity of the area, i.e., there may be some stress on the side of the host population due to the presence and behaviour of tourists in the area. Therefore it is important to not only evaluate the economic benefits of a heritage site, but also identify and counteract potential negative environmental and social impacts.

Potential risks and benefits of investing in the development of a cultural heritage site and requirements for impact studies

According to the French cultural economist Xavier Greffe (2002), a general assessment of the potential risks and benefits of investing in the development of a cultural heritage site should consider:

– the relative economic importance of the site relative to other economic activities in the area, and
– the degree of economic integration of the site in the local economy, i.e., its capacity to produce the goods and services that the non-resident visitors will consume.

	Strong integration	**Weak integration**
High economic importance	Conflicting effects (a site in a peripheral area with diversified economy)	Critical effects (an isolated site or small historic town in a rural area)
Limited economic importance	Very positive effects (a site in a metropolis)	Generally positive effects (a larger historic town)

Table 11.2: Effects of investments in a cultural heritage on the local economy, based on Greffe 2002 (reproduced and commented in développement culturel 2003)

The main reasons for this assessment are: If the economic importance of the site for the area is limited, the investment is unlikely to destabilise the local economy, and a high integration will allow for reaping most of the profits within the area. In contrast, an investment in a situation of high economic importance but weak integration is problematic as it will raise the relative weight of the site in the local economy which, however, may not be capable of capturing enough benefits from it. Unfortunately, this is often the case for isolated sites and small historic towns in remote, rural areas that have high expectations for investments in cultural tourism development.

Heritage authorities or sites who commission an impact analysis should be aware of the many requirements for a solid analysis. According to John L. Crompton 'shenanigans' that are used to produce favourable impact figures comprise the following procedures:

> "including local residents; inappropriate aggregation; inclusion of time-switchers and casuals; abuse of multipliers; ignoring costs borne by the local community; ignoring opportunity costs; ignoring displacement costs; expanding the project scope; exaggerating visitation numbers; and inclusion of consumer surplus" (Crompton 2006).

Standardized and easy-to-use tools for economic impact analysis could be of great help. An example of such a tool is the 'Money Generation Model' for national parks in America. This is a set of MS Excel workbooks that allow for calculating estimates of the impacts that park visitors have on the local economy in terms of their contribution to sales, income and jobs in the area (MGM2 – Web site, http://web4.canr.msu.edu/mgm2).

The development of such simple tools for heritage site managers should be a matter of priority. ICT could prove to be a useful mechanism for automating such economic management tools and may allow results to be aggregated regionally, nationally or across Europe.

11.5.3 Non-market valuation of heritage

There are different methods for capturing the value people attach to CH places and objects. These methods can be subdivided into market and non-market analyses. Market analyses are the traditional analyses carried out by economists which identify direct and indirect expenditure effects. While these techniques can determine the more easily measurable economic impacts of a cultural heritage site, they do not reveal the full range of values produced by a site.

Many heritage goods and services are not traded in markets. Non-market analyses try to capture the values and benefits that are not picked up by the market valuations. These non-market valuations can be subdivided into (indirect) revealed preference and (direct) stated preference methods:

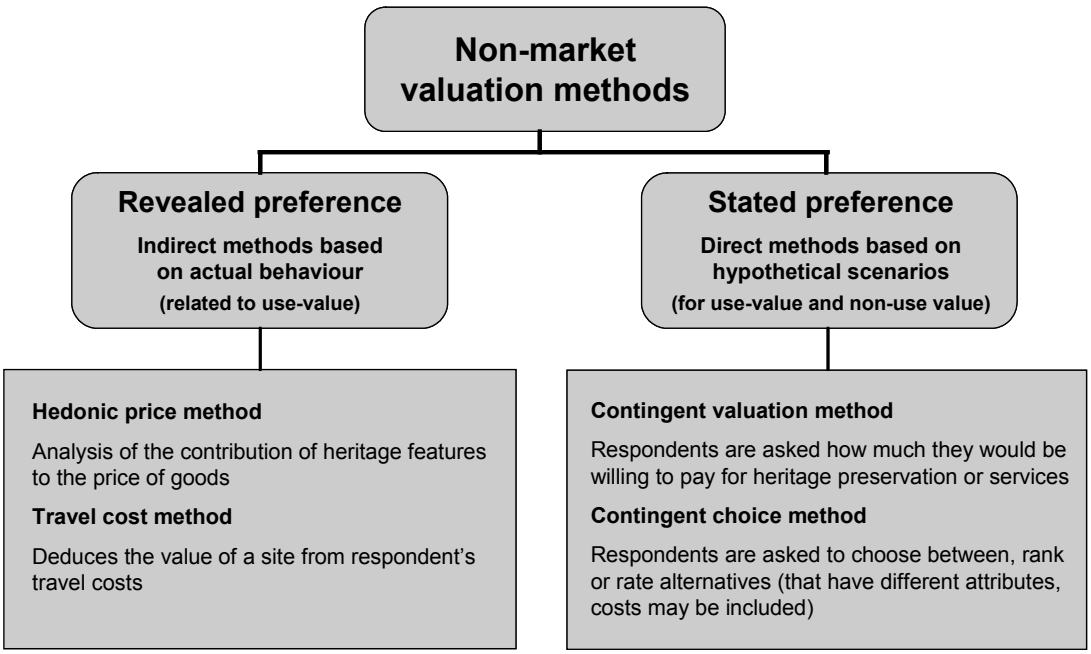


Figure 11.4: Overview of non-market valuation methods that have been applied to heritage sites

Valuation with indirect, revealed preference methods

Indirect valuation methods exploit the fact that preferences and consequently the implicit value for benefits and costs are indirectly revealed when people purchase marketed goods or services that are related to the heritage asset being researched. These methodologies rely on actual consumer behaviour to determine values and benefits. There

are two principal non-market valuation techniques that exploit consumers' revealed preferences, hedonic price analysis and travel cost analysis.

Hedonic valuations assume that individuals place a value on the characteristics of a good, rather than the good itself. In this way, the price will be a surrogate for the value of a set of characteristics, including cultural heritage characteristics that people consider important when purchasing the good. House prices are the most common vehicle for estimating the value of environmental amenities, although other vehicles such as wages can be used.

In the United States, the creation of historic preservation districts has been used as a means of regenerating urban areas (Kilpatrick 2000). These districts encompass both residential and commercial properties. The hedonic price method has been used to evaluate the value and benefits of the creation of historical preservation districts in Sacramento, California. The results suggest that the districts have a positive impact on residential property prices in four out of the six districts surveyed (Clark and Herrin 1997). In Australia, a hedonic price study of historic properties in Sydney's upper north shore determined that heritage-listed houses were found to command a price premium over unlisted houses. This was considered to be an indication of the combined value of the heritage character of properties and their listing status. The historical significance of the heritage properties was considered to have had a beneficial influence on price (Deodhar 2004).

The Travel Cost Method is an indirect valuation method in which the costs of travel are used as a surrogate for the value of the visit. The underlying assumption of the travel cost methodology is that the amount individuals are prepared to pay to travel to a cultural heritage site is a reflection of the value of the goods and services provided by that heritage site. Using this framework, the expenses that individuals incur in order to visit a site, in terms of time and transport costs, are a proxy for the 'price' of access to the site.

As with the hedonic price methodology, travel cost has not been widely applied to the valuation of cultural heritage sites. Since the mid-1960s it has been widely applied as a mechanism for valuing environmental goods. It was not until 1994 that the methodology was transferred to the valuation of cultural heritage, when Fernand Martin attempted to value the Museum of Civilisation in Quebec, Canada (Martin 1994). Half a decade later Anna Bedate, Luis César Herrero, and J. C. Sanz used the technique to estimate the demand curve for three different cultural heritage sites in the Castilla y León region of northern Spain. These included the historic village of Uruena, the Museum of Burgos in the provincial capital, and the historic Cathedral of Palencia. The Iberian Organ Festival was also studied (Bedate, Herrero and Sanz 2004). Later Joan Poor and Jamie Smith conducted a valuation using visitor data from three years (1999–2001) from the archaeological site and reconstructed historic town at St. Mary's City, Maryland, USA (Poor and Smith 2004). In 2004 Anna Alberini and Alberto Longo conducted a series of innovative travel cost studies on four heritage sites in Armenia: one first-century A.D. temple and three monasteries (Alberini and Longo 2006).

Valuation with direct, stated preference methods

The Contingent Valuation Method (CVM) is a non-market valuation technique based on stated preference, which tries to extract an estimation of the 'willingness to pay' for a good or service from users and non-users. This is achieved by eliciting a monetary figure from respondents based on hypothetical scenarios. It is designed to capture the value of a cultural heritage site or the value of some potential investment in a site.

Contingent valuation is an accepted way of determining a financial proxy for non-use values in cultural heritage. These 'passive use' values that do not involve a market and may not even involve direct participation are extremely difficult to quantify otherwise. The methodology has been applied to cultural heritage sites across the world with over 60 studies conducted by 2007 (McLoughlin, Kaminski and Sodagar 2007a, 98–121). However, this pales into insignificance when compared with the more than 2000 valuations conducted in the field of environmental economics (Carson et al. 2000).

Choice modelling is similar to contingent valuation in that it can be used to estimate both economic and non-use values for cultural heritage sites. Like contingent valuation, it is a hypothetical method which requires individuals to make choices based on a hypothetical scenario. Unlike contingent valuation, it does not directly ask respondents to state their values in financial terms. These values are inferred from the hypothetical choices that the respondents make. Contingent choice is particularly valuable for the evaluation of the outcomes of several policy options, where non-use values are important. Contingent choice can be used to rank options as well as estimate financial values.

The contingent choice methodology has started to be applied to cultural heritage in recent years. Research by Maddison and Foster (2001) used a choice experiment at the British Museum (UK) to determine the willingness to pay to reduce congestion in the museum. This was followed by a study conducted at the Galleria Borghese

Museum (Italy), which combined a contingent valuation survey with a choice experiment. This was used to determine willingness to pay for entry to the Galleria, and the provision of additional (multimedia) services and of exhibitions (Mazzanti 2003a, b).

With techniques such as contingent modelling and contingent valuation sufficiently well advanced this would be a profitable area of research (cf. Morey 2001, who provides many practical suggestions). However, 'contingent' valuations are resource intensive and there is still much methodological debate in academic circles. This has led some authors such as Bruno Frey (1997) to propose that given the difficulties and uncertainties associated with this type of economic analysis, popular referenda may be an alternative means of gauging the (multiple) values of cultural heritage and making conservation decisions.

Tools for non-market valuation of ICT

It is clear from this overview of non-market valuation methods that the stated preference methodologies have been used more than revealed preference techniques. The application to ICT has been very low – valuations have concentrated principally at the site level. The valuation of multimedia services at Galleria Borghese Museum is at present the only non-market study that considers ICT in a heritage context.

With such limited data available regarding willingness to pay for ICT at cultural heritage sites the potential for 'benefit transfer' (see below) of the results is limited. It should also be noted that public institutions often do not charge money for onsite and online ICT services, exhibitions, etc., and many visitors appreciate using them for free. However, research needs to be directed towards determining the cost/benefit ratio for the institution and community for the public investment.

Valuing Web sites and online exhibitions has proved problematic. There is usually no cost for the service or the content for users, and no revenue for the institutions providing the service. In the absence of such data valuations are difficult to make. But some simple tools do exist. These can be used by heritage site managers to measure the effect of a Web site or exhibition on the local economy. For example, it has proved possible to place a yardstick monetary figure on the value of a heritage site's internet induced visits (or even the value of a specific Web site) to the local economy. This is achieved by using a questionnaire-based approach to determine the value a site has to the local economy and then determining how many visitors found out about the site using the Internet or a specific Web site. The combination of these two figures provides an indication of the monetary value of either the site's Web page or the Internet-induced visits (McLoughlin, Kaminski and Sodagar 2007a, 94–97)

Simple tools such as this can provide an important mechanism for heritage site managers to justify expenditure in ICT to funding authorities. In view of the resource limitations of the heritage sector, the development of further simple, robust and user-friendly tools is an important area for future research.

'Benefit transfer' – possibility of transferring valuation results

As market and non-market valuations of cultural heritage sites are costly, there is the question if already available benefit estimates for a site or a number of sites could be used for the valuation of another site (so called 'Benefit Transfer Method'). Ståle Navrud and Richard Ready (2002) discussed this possibility based on an overview of studies on heritage sites that were available in 2001 (most of them based on the contingent valuation method), and identified a number of future research needs:

- They consider "the most pressing need in this area" to be more studies on the diverse array of heritage sites, but add, "we are not hopeful that we will ever reach a point where 'enough' studies have been conducted".
- One important lesson taken from the environmental valuation literature is that benefit transfer for policy issues at a geographically different but similar site will often be unreliable. But, certainly, "…for benefit transfer to work at all, it must be between sites that are very similar, both in the physical good being valued, the change in the good and the population holding the values".
- Because heritage values are highly site specific, Navrud and Ready "…do not anticipate that there will ever be a catalogue of values from which decision makers can select an appropriate number for the new policy issue they face". They consider that groups of cultural heritage sites may have similar values; however, the few available studies do not allow for judging the extent to which values vary.
- As a particularly critical research need they consider "…valuation studies designed to address specific policy problems, rather than provide general values for the goods. Knowing the amount that a visitor is willing to pay to gain entry into a cathedral does not help us decide whether to restore damaged portions".

– Furthermore, research into tradeoffs among competing objectives, for example, between access and deterioration, would be very beneficial. Navrud and Ready emphasize that non-market valuation techniques are "…uniquely well suited for considering issues that involve tradeoffs between use values and non-use values".

In a more recent discussion of benefit transfer in the valuation of cultural heritage sites, Patrizia Riganti and Peter Nijkamp also stress that few applications have been policy-oriented. However, they think that "…the policy need for benefit transfer it is likely to be more impingent in the future. Therefore, research efforts should be directed to target this need, aiming to overcome the current obstacles" (Riganti and Nijkamp 2005).

11.5.4 Instruments for capturing different impacts of heritage sites

Most impact studies undertaken in the heritage sector to-date have usually focused on a single impact dimension at one moment in time. There is scope for greater research devoted to the broader study of the heritage system. Holistic models such as the one shown in Figure 11.4 below highlight the complex, multi-dimensional nature of impact, and how multiple influences effect impact.

Such models offer a guide to which impacts should be examined, given the specific circumstances of a cultural heritage site. They can allow also for accommodating the inclusion of numerous measurement methodologies and indicator-based approaches.

Research in this sphere would enhance the understanding of the heritage system and give heritage site managers a much clearer comprehension of how their activities can influence impact. In addition, site managers need easy-to-use tools for capturing and measuring the impact of the site with regard to different dimensions, not only economic but also social and environmental impacts.

Cost and complexity of impact evaluations

It is clear that for each dimension of impact that is considered there are levels of study that increase in cost and complexity. In economic impact studies the simplest, and therefore cheapest, methods revolve around the study of cash flows derived from visitor numbers; nonetheless, as more information is gathered the cost increases. For example, gathering information about visitor profile, or visitor expenditure at the site increases both the cost and the complexity of analysis. If a heritage site wishes to conduct a more complex analysis such as a questionnaire-based non-market valuation, the cost increases markedly, often beyond the resources of most heritage sites.

The same issues apply to all areas of impact being studied, whether individual, economic, social, or environmental. For example, an assessment of the social impacts and outcomes of a site increases in cost and complexity from simple measurement of numbers of visitors, to determine the socio-economic group of those visitors, and conduct studies of community identity and social cohesion (see Figure 11.5). As more human resources are required to obtain the data and conduct the subsequent analysis, costs and complexity increase. This is especially the case in the study of social impacts where higher-level information requires the use of interviews to acquire the raw data. Similarly, with an assessment of the environmental impact of a heritage site, simple calculations of energy use are relatively easy to obtain, but quantifying the percentage of recycled waste and carbon emissions requires more resources to acquire the information (see Figure 11.6).

When deciding on which activities to study consideration must be made of costs and complexity. Sites may wish to measure impact using sophisticated techniques, but the time and resources required to do so may be prohibitive. While the question of advances in methodology will be important to help reduce the complexity for heritage site managers (or outside agencies that are commissioned to conduct the research) the area of data capture will also be an important element in the reduction of costs for heritage sites.

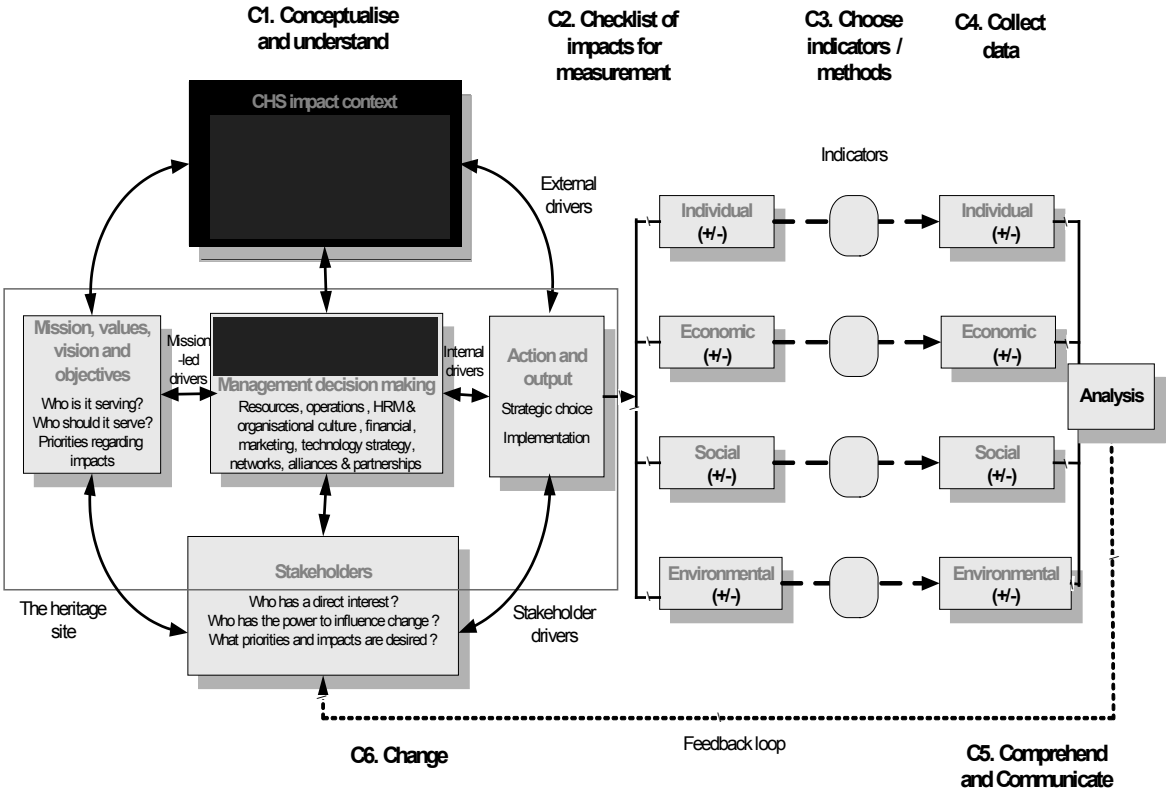


Figure 11.5: A conceptual model of the heritage system and its measurement systems (McLoughlin, Kaminski and Sodagar 2007b: 19)

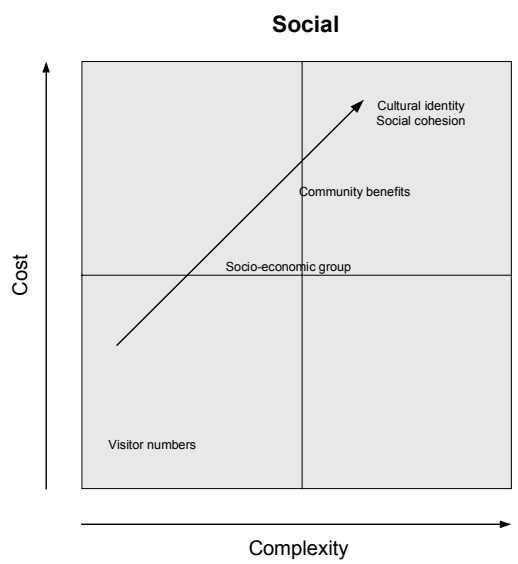


Figure 11.6: A cost complexity-matrix highlighting the position of various social auditing, valuation and impact methodologies

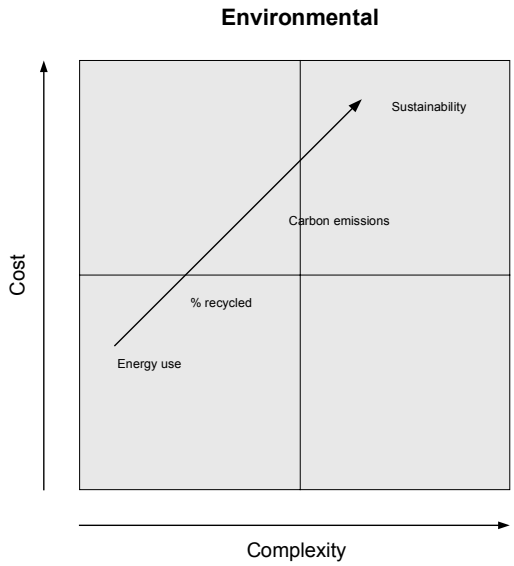


Figure 11.7: A cost complexity-matrix highlighting the position of various environmental impacts and outcome assessment methodologies

Cost-effective and easy to employ ICT-based mechanisms of data capture

Heritage sites have long been reliant on questionnaire-based visitor studies for much of their work. ICTs provide an opportunity to reduce acquisition costs, but the area is woefully under-explored. For example, the ability of different devices to capture user or environmental data will vary considerably. There may be areas where fixed or

portable technologies are more practical to employ and may be more or less cost-effective. In the evaluation of the cost-effectiveness of the technologies their total cost of ownership must be considered.

Moreover, in on-site and online visitor studies there is the question of which approaches are likely to find a sufficient rate and quality of response. Visitors are increasingly reticent about using Web-based surveys, But they have been shown to be more likely to provide responses to questionnaires provided on portable devices. These may take the form of questions that visitors can respond to on a device or simply providing an interviewer with a portable digital device to input visitor responses as they are given. If survey data is captured directly in digital format, transcription and analysis costs can be reduced considerably.

Brief summary of needs of research and guidance

It is apparent that there are a number of short- to medium-term research questions that need to be addressed in order to leverage the capability of capturing and analysing the societal impact of cultural heritage.

Methodologies and instruments for capturing different impacts of heritage sites are a particularly important field of research and development. This includes the refinement of methodological frame-works, adaptation and assessment of the applicability of specific methods, and development and testing of novel approaches and tools for data acquisition. Furthermore, standardization, identification of best practices and lessons learned, and guidance material are also of high importance.

Research and training in this sphere should enhance the understanding of the heritage system and give heritage site managers a much clearer comprehension of how alternative choices of activity and investment can influence impact in economic, social and environmental terms.

There also is a need for linking plans and activities for leveraging the impact of sites more fully into medium- to longer-term development strategies of regions and cities, e.g., sustainable development and quality of life or cultural cluster or/and cultural tourism strategies.

The heritage sector lags far behind other comparable sectors with regard to the number of impact studies and valuations conducted. For example the heritage sector has initiated over 60 studies world-wide using the 'contingent valuation methodology' as a mechanism to determine economic and other values of different sites. In the field of environmental economics, where the methodology originated, more than 2000 studies have been conducted. The reason for this dichotomy is principally an issue of cost – the heritage sector is traditionally resource-poor.

Therefore it is very important to provide heritage sites with cost-effective and easy-to-deploy methods and tools for capturing data for impact evaluations. Obtaining quality data is crucial for the heritage sector. Without this foundation, the sector will be unable to look at the big picture of the impact that it has on society and will only be able to work with isolated islands of data.

The need to reduce costs and complexity of impact and evaluative research for heritage site managers is clear. Without such research the burden of impact studies will divert critical resources away from core business processes at heritage sites, or impact will simply be ignored.

The challenge therefore is to produce models and tools that can be used by the heritage sector which produce robust, comparable results, but whose cost and complexity is reduced to such an extent that they are accessible to small and medium-scale heritage sites. It is a well known fact that methodologies that are complex and costly are not adopted, unless imposed from above.

ICTs certainly can be highly supportive in capturing, processing and analysing data on different impacts of heritage sites. Besides guidance on how to best employ novel tools, e.g., with respect to rate and quality of visitor response, more knowledge about how to reduce their total cost of ownership would be beneficial.

There is also scope for greater research devoted to deepen the understanding of heritage impact drivers through acquiring data at similar sites across Europe. There appear to be considerable differences between the data available from various European countries. There is currently a clear north–south divide regarding such data availability, with more data being available from northern Europe and other 'old' EU member states.

11.6 Issues in the development of sustainable cultural tourism

Cultural tourism here is understood as visits by persons from outside the host community motivated wholly or in part by interest in the cultural, historical, artistic and lifestyle offerings of a region, town or institution. This offering may, for example, comprise cultural landscapes, heritage sites, visual and performing arts, traditions and leisure pursuits of the host community. Among the related activities are sightseeing, attendance at cultural events,

visits to museums and heritage places and mixing with local people (cf. ICOMOS-ICTC 1999[2002], 22; Lord 1999, 3).

Cultural tourism is seen as a particularly interesting segment of the tourism industry and a key factor for the economic development of many European regions and cities. For example, the report *City Tourism & Culture*, of the World Tourism Organization and European Travel Commission, emphasizes that "…culture is the single most important motivation for city trips although relatively few visitors view themselves as 'cultural tourists'." Indeed, only about 20% of city tourists rate culture as their prime motivator, but a far greater number of tourists are actually involved in cultural activities while on a city trip (cf. WTO-ETC 2005, viii).

The important role of cultural tourism is particularly clear in the case of large 'cultural cities' (e.g., Amsterdam or Barcelona) and renowned smaller historic and arts cities (e.g., Bruges or Salzburg), and today ever more towns with interesting historic and other features seek to develop their potential for such tourism. As the European Institute of Cultural Routes write on their Web site, "…interest in tourism has spread rapidly throughout many small and medium European cities, which previously have not considered themselves as tourist destinations" (EICR 2008).

It is expected that the competition for visitors between cultural tourism destinations will increase considerably. Newcomers and established destinations will need to be very inventive to stand out among the many competitors. In particular, the many more small and medium-size towns in Europe – particularly, from Central and South-East Europe – who present themselves as 'historic town' will have to work hard if they aspire to become a distinct place in the cultural tourism landscape.

Besides the expected competition among historic towns, there are also ever more projects that aim at upgrading the accessibility and experiential value of existing heritage sites as well as developing new places and routes for cultural tourism. Therefore it will be important to consider not only the possible favourable impacts of these ventures, but also the many critical aspects of tourism particularly for smaller places with limited tourism carrying capacity.

The following sections describe first some favourable and critical aspects of cultural tourism, and, secondly, required research, guidelines and advice are identified that could help exploit the favourable aspects while preventing potential negative impacts.

11.6.1 Favourable aspects of cultural tourism

The increasing interest in cultural tourism is a function of the fact that culture and heritage tourists differ from the statistically average tourist profile in several respects. Moreover, it is understood that strong societal trends work in favour of cultural tourism. The following are some key trends that will drive cultural tourism as well as possibly having favourable economic, social and environmental impacts at tourism destinations:

People increasingly look for authenticity and meaningful experiences:

In tourism this favours activities that are related to culture, heritage, historic depth, human continuity and spirituality and clearly distinguishes cultural from 'theme park' tourism (cf. Lord 1999, 6).The more 'industrial' the typical travel package and holiday resort become, the more people will look for meaningful experiences, authentic environments, landscapes, towns and villages with character, cultural specificities, and traditional rituals of social life. There are, of course, some delicate questions implied when talking about authenticity and meaningful experiences in the context of tourism products (Chhabra, Healy and Sills 2003; Cohen 2004; Meethan 2001; Rowan and Baram 2004).

Self-development and personal fulfilment:

Many people suffer from pressure of work that seems to intensify each year, have a bad work–life balance, and little or no time for self-development. The Future Foundation found that personal fulfilment was the top priority for 50% of British adults in 2004, compared with 25% in 1983 (cf. Ahuja 2006). The quest for personal fulfilment spurs 'niche markets' such as creative cultural tourism, which provides opportunities for self-development, and allows tourists to change their role and develop a closer relationship to places and communities (Prentice 2000, 2001b, 2003; Richards 2002; Richards and Wilson 2006). Also, 'volunteer tourism' provides opportunities for such relationships (Mustonen 2005; Singh 2004; Wearing 2001).

Cultural tourists tend to spend more money while on vacation:
The ATLAS Cultural Tourism Project (ATLAS – Association for Tourism and Leisure Education 2002) found that the daily expenditure of cultural tourists is over €70 whereas visitors on a touring holiday spend €52, beach tourists €48, and people on a city break €42. However, it was also noted that cultural tourists on average stay in an area for a shorter period than do beach tourists. Cultural tourists have more money available for travel and related expenses because on average they have a higher education level and better jobs. According to the survey of the ATLAS Cultural Tourism Project, over half of cultural tourists had some form of higher education (compared with about one third of the EU population), often professional (34%) or managerial occupations (18%), and salaries about one third higher than the EU average.

Heritage tourists are more likely to be from an older age group:
Purposeful cultural tourists who want to visit historic towns, monuments, archaeological sites and museums tend to be from older age groups. Hence, the trend towards the 'aging society' works in favour of cultural tourism destinations. Older age groups are not only growing in proportion, on average they also have the highest spending power and today are ever more willing to spend rather than to save their money. For example, in a survey of German seniors aged between 50 and 79, almost 50% agreed with the statement, "I rather prefer to live a good life than saving money all of the time". Ten years ago, only 25% could identify with this phrase (GfK 2002). The seniors will also have relatively more time available for travel, which they may choose to make off-season. They can also be expected to be increasingly savvy, demanding and critical. This means that they will look for a high quality heritage tourism environment.

Important role of women:
Women generally exhibit a higher cultural consumption and participation in cultural activities than men. Accordingly, they make up a higher proportion of cultural tourists. Women also increasingly control more income and make decisions regarding family vacations. With respect to groups of travellers, women are often the tour group promoters and planners. In short, culture and heritage destinations should appeal to women who are planning individual, family or group travel.

Quality demands of cultural tourists:
It is worth noting that culture and heritage tourists tend to be more quality conscious regarding the natural and urban environment they visit, the available accommodation, gastronomy, etc. For example, they are not necessarily attracted to large standardized hotels and may look for character, style or charm in their accommodation. 'Boutique hotels' that are located in historic buildings and use local quality crafts are expected to become increasingly popular (EC 2002c, 7). An increasing level of concern about the environment among culture and heritage tourists means that tourism service providers will be expected to contribute to the sustainability of the natural environment and local communities.

Diversification of tourism offer:
For many tourism destinations the development of heritage sites and other cultural offerings allow for a diversification of their tourism portfolio. For example, many Southern countries' tourism markets are pigeonholed into 'sun and sea' mass tourism. Following countries such as Cyprus, Greece and Turkey, who emphasize their heritage from the classical period, others also seek to offer alternative or supplementary opportunities for enjoying and learning more about the destination. The Croatian coast of former Yugoslavia and parts of North Africa, especially Tunisia, are examples for such attempts to benefit from heritage assets and other place-specific culture (gastronomy, events, handcraft, etc.). This also includes former industrial places such as historic dockyards which have been developed into tourist attractions (e.g., Bermuda's Royal Naval Dockyard). Also, the tourist segment of backpackers can be interesting to address. For example, in the 'Forgotten Villages' project in northern Syria an archaeological park has been developed and abandoned houses converted into tourist lodgings (Hammoudi 2007).

11.6.2 Critical aspects in cultural tourism

Cultural tourism also has some critical aspects which regions and towns should consider when investing in the development of heritage sites:

Rapid consumption of heritage places:
Even major heritage-rich destinations (e.g., Bath or Venice) rarely see an average length of stay of tourists of more than two days. In contrast, beach resort holiday-makers on average stay for around 10 days. The situation of small heritage towns is even worse as most of them will primarily receive day-trip visitors, whose stay is better measured in hours; e.g., a 4–6 hour stay of holiday excursionists in Valetta or an average of 2.5 hours in Delft (cf. Ashworth 2004).

Return visits are unlikely:
A further major problem is that heritage attractions tend not to generate return visits. As Gregory Ashworth writes, "…much heritage tourism could be labelled Michelin/Baedeker collecting. Tourists have pre-marked sites and artefacts that must be visited if the place is to be authentically experienced. Once 'collected' a repeat is superfluous and the collection must be expanded elsewhere. Ironically, the more unique the heritage experience, the less likely it is to be repeated" (Ashworth 2004, 5).

Mummification of heritage towns:
Ashworth also notes that "…the more renowned and unique the heritage product, the more difficult it is to renew and extend the range of heritage products on offer. Sites can become imprisoned in the immutable uniqueness of the site and the unvarying but stringent expectations of visitors." Similarly, when summarizing discussion highlights from the UNESCO 'Partnerships for World Heritage Cities' symposium in 2002, the authors write that in many cities the historical areas "…have become well-maintained ghettos", which is "…often an expression of the adverse effects of heritage policies that invest in historical centres in ways, which end up depriving them of their primary functions". They also warn that this "…can result in frozen, mummified historical centres cut off from the city's modern soul and increasingly irrelevant to all but sightseers and tourists" (Robert, Pharès and Sauvage 2003, 86 and 93).

Cannibalization of heritage offerings in cultural cities:
The ATLAS Cultural Tourism Project found "…evidence of a trend towards greater dispersion of visitors among different cultural attraction types in the destination, and in particular a shift from 'heritage' attractions towards 'arts' attractions. The figures for 2001 show museums having no growth in the proportion of visitors since 1997 and monuments losing share. On the other hand art galleries, performing arts attractions and festivals have all increased their share of visitors in recent years" (ATLAS – Association for Tourism and Leisure Education 2002).

The observed greater dispersion of visitors in urban cultural tourism destinations and loss of cultural heritage institutions in visitor numbers is very likely the result of the huge investment of many cities in new cultural quarters, arts attractions, and a multitude of co-sponsored events. This investment is a strategy of competing with other cities by presenting an ever richer portfolio of culture and lifestyle offerings. Particularly, it is a response to the trends that tourists increasingly become 'multi-optional' (i.e., want to have the option of enjoying a variety of travel experiences) and seek to consume "more in less time" (i.e., try to pack more activities into more frequent trips of shorter duration). In this development, cultural heritage institutions such as traditional museums may be increasingly side-lined if they cannot afford to host a 'blockbuster' exhibition.

Even more critical are situations where heritage places are cannibalized by projects that seek to exploit historic themes in inappropriate ways. One recent example is the proposed 'Dracula Park' project near the World Heritage site Sighisoara in Romania (Jamal and Tanase 2006).

Attractive small places will rapidly face the negative end of the Tourist Area Life-Cycle:
Many easily accessible heritage sites and small historic towns that attract large numbers of visitors (most often day-trip visitors) experience negative effects. They are in the decline stage of the Tourist Area Life-Cycle model, and decisive actions would need to be taken to better the situation (not to speak of a possible recovery and rejuvenation stage). The damage caused by mass tourism on heritage sites is felt in many places across Europe. There also seems to be a particularly high risk of tourism breaking historic continuity, context and memory in small heritage towns. The typical conflict of developing cultural tourism may be unavoidable: The unique character of a living historic environment, which is marketed to potential visitors, should be preserved. Yet, tourism development brings crowds of visitors, tourist shops that offer an assortment of cheap imported products, a theatrical illumination of monuments is installed, 'folkloric' entertainment is offered, etc (Drdácký 2002)

Impact of tourism development on local retail, workshops and residential spaces:
There also often occurs a gradual displacement of economic functions at tourist place. For example, the higher rents that can be earned from the tourist trade can force out of historic centres traditional retailers and small workshops, so that the residents can no longer find there the assortment of goods or particular services they are looking for (cf. Drdácký 2002; Russo 2002). Furthermore, the development of historic, but run-down areas of cities into attractive places "…can bring gentrification and lead to city centres inhabited only by the rich classes and occupied by tourists and private businesses" (Pascual 2004, 3).

Degradation of public spaces:
Graham Brooks, Chairman of the ICOMOS International Cultural Tourism Committee, points out many negative impacts from the residents' perspective, which will be the more grave the smaller and more traditional the visited places are:

> "Congestion from crowds of visitors, increased levels of traffic and parking congestion from tourist buses and motor vehicles, and the resulting disruption to normal daily life, can be a major source of irritation and frustration for local residents. They can feel excluded from their own special places by large crowds, long queues or thoughtless behaviour by visitors who do not understand the local culture or cultural practices, or by inequitable entry prices. Tourists often arrive in large groups or at peak periods, heavily impacting on the capacity of public spaces that may have traditionally served a relatively small population. Day-trip visitors from cruise ships or nearby recreational destinations often place extraordinary pressures on local resources. As tourists explore the quieter streets and spaces, local people can feel as though they have been reduced to objects of curiosity, with their privacy invaded, almost like animals in a zoo. Late night noise and other inappropriate behaviour can arise when large numbers of tourists congregate in relatively restricted sections of the city" (Brooks 2005).

The typical consumption patterns and potential negative impacts of heritage tourism described above make a proactive tourism management by regional and local authorities and site managers a necessity. If they allow heritage sites, public spaces and other local resources to be exploited, degraded and damaged through excessive tourism, these resources will be lost for everybody – the locals as well as the visitors, who can no longer appreciate them.

The tourist area life-cycle certainly has reached a critical stage if heritage places become degraded and the local people face a situation where they must compete with tourists for space, local services and opportunities to enjoy their life. Local authorities should ensure that the cycle does not reach this point.

In short, the heritage site and the host community should be the most important stakeholders in cultural tourism development, and local authorities must understand that protecting the site and the quality of life of the local people are essential for sustaining tourism in the longer term.

11.6.3 Need for targeted research and advice on sustainable tourism development

There is a clear demand for targeted research, guidelines and advice in cultural tourism development strategies that take advantage of potentially positive societal trends (e.g., demand for authenticity, meaningful experiences, high-quality services, environmental concern), but, at the same time, prevent potential negative impacts on heritage sites and the host community as far as possible.

WTO definition of sustainable tourism

The report *Our Common Future* from the World Commission on Environment and Development, known as the Brundtland report (Brundtland 1987). defines sustainable development as follows: "Sustainable development meets the needs of the present without compromising the ability of future generations to meet their own needs."

The definition of 'sustainable tourism' of the World Tourism Organization builds on the formulation of the Brundtland report:

> "Sustainable tourism development meets the needs of present tourists and host regions while protecting and enhancing opportunities for the future. It is envisaged as leading to management of all resources in such a way that economic, social and aesthetic needs can be fulfilled while maintaining cultural integrity, essential ecological processes, biological diversity and life support systems."

A more detailed conceptual definition of the World Tourism Organization considers that sustainability principles should "…refer to the environmental, economic and socio-cultural aspects of tourism development, and a suitable balance must be established between these three dimensions to guarantee its long-term sustainability".
Thus, sustainable tourism should:

"1) Make optimal use of environmental resources that constitute a key element in tourism development, maintaining essential ecological processes and helping to conserve natural heritage and biodiversity.
"2) Respect the socio-cultural authenticity of host communities, conserve their built and living cultural heritage and traditional values, and contribute to inter-cultural understanding and tolerance.
"3) Ensure viable, long-term economic operations, providing socio-economic benefits to all stakeholders that are fairly distributed, including stable employment and income-earning opportunities and social services to host communities, and contributing to poverty alleviation.

> "Sustainable tourism development requires the informed participation of all relevant stakeholders, as well as strong political leadership to ensure wide participation and consensus building. Achieving sustainable tourism is a continuous process and it requires constant monitoring of impacts, introducing the necessary preventive and/or corrective measures whenever necessary. Sustainable tourism should also maintain a high level of tourist satisfaction and ensure a meaningful experience to the tourists, raising their awareness about sustainability issues and promoting sustainable tourism practices amongst them" (WTO 2004a).

Cultural tourism and sustainable development: Charters and declarations

There are a number of charters, declarations and similar documents on cultural tourism and sustainable development. Among the most important are the 'Global Code of Ethics for Tourism' of the United Nations' World Tourism Organization (WTO 1999[2001]) and the ICOMOS 'International Cultural Tourism Charter' (ICOMOS 1999[2002]).

Recently, there has been a mushrooming of declarations, which may indicate an increasing unease regarding the commercialization and loss of local cultural heritage through tourism activities. Among them are the 'Malta Declaration' of the pan-European federation for cultural heritage Europa Nostra from May 2006 (Europa Nostra 2006a, b) and the 'Dubrovnik Declaration', which was issued by the Culture and Education Committee of the Council of Europe's Congress of Local and Regional Authorities together with the European Association of Historic Towns and Regions in September 2006 (Council of Europe/European Association of Historic Towns and Regions 2006).

For example, Europa Nostra's declaration wants to see EU Institutions, the Council of Europe, Europe's national, regional and local governments, and heritage organizations "…champion sustainable growth in the cultural tourism market, while also taking positive steps to prevent damage and degradation of the cultural heritage by careful planning to maintain the volume of tourists to heritage travel destination areas to within optimum sustainable limits", and promotes "…the idea of a European Label for Sustainable Cultural Tourism".

Research for sustainable cultural tourism strategies

Sustainable tourism is a complex field of research which spans economic, socio-cultural and environmental aspects of a tourism destination that are closely interlinked. Moreover, while sustainable tourism is envisaged as a well-balanced situation, it is a moving target that must be aimed at amidst dynamic change, conflicts, complex interdependencies, uncertainty, and impacts of factors that are not all controllable at the level of the destination (cf. Harris, Griffin and Williams 2002).

Below important approaches in the research on sustainable tourism are summarized. It should be noted that sustainable tourism has become an increasingly popular field of research since the late 1980s. In 1999, a bibliography of the World Tourism Organization on the theme identified and reviewed about 100 books and 280 articles that were considered as relevant contributions (WTO 1999), and the volume of output certainly has not decreased since then. Hence, the following paragraphs can provide only a brief overview and do not fully cover the debate on sustainable tourism that has been criticized as being to a large part "…patchy, disjointed and often flawed with false assumptions and arguments" (Liu 2003).

Tourist Area Life-Cycle (TALC) model:

There are many publications available which describe applications of the Tourist Area Life-Cycle (TALC) model. The model was introduced by Richard W. Butler in 1980 and proved to be a useful reference point for describing

and discussing stages of tourism development at different types of destination. According to the basic model, destinations progress through the six stages of exploration, involvement, development, consolidation, stagnation, and decline or rejuvenation (Butler 1980). Most attention of course has been devoted to the critical later stages of the life-cycle (Priestley and Mundet 1998).

The model has been applied to a large number of tourist destinations, in particular, islands and coastal resorts. However, many publications on the TALC of destinations are descriptive in nature and often do not offer more than a compilation of data and observations on particular circumstances and recent developments at a destination. Better results have been achieved if an attempt was made also to identify the carrying capacity of the destination (cf. Butler 2006a, b; these volumes provide a selection of outstanding contributions on theoretical and conceptual issues, applications and modifications of the model).

Applications of the TALC to historic towns and sites are rare, although, according to Antonio P. Russo "it is in heritage cities that the full developments of the cycle assume the most significant tracts" (Russo 2002 – with good empirical data for Venice; see also Russo 2006).

Carrying capacity of tourist destinations:

The concept of carrying capacity is well known in disciplines such as ecology, human geography, social anthropology and archaeology, where it is generally understood as the maximum number of individuals that a given environment can support without detrimental effects. In the context of tourism, the concept refers to the ability of a destination to absorb certain levels of tourism infrastructure and visitors before the values of the place are diminished to an unacceptable degree.

The carrying capacity of a destination can be defined and identified from different angles, physical, psychological (or perceptual), social, and economic, which require different methods of data capture. For example, the social carrying capacity relates to the level of tolerance of the host population for the presence and behaviour of tourists in the destination area, and/or the degree of crowding that visitors are prepared to accept (O'Reilly 1986).

The concept of carrying capacity has been widely discussed and a certain level of standardization in its application has been achieved (cf. Butler 1996; Clayton 2002; Coccossis et al. 2001; Coccossis and Mexa 2004, Lindberg et al. 1997; Prideaux 2000). The research has also informed efforts to define limits of use and development that are permitted within a controlled heritage area. Related methods of tourism management are the 'limits of acceptable change' approach and various visitor management and impact assessment approaches (with respect to historic town centres see Glasson, Godfrey and Goodey 1995; Pickard 2004).

Frameworks for indicators of sustainable tourism:

Indicators play a key role for monitoring tourism destinations and adjusting policies and measures if sustainability targets are not met (White et al. 2006). Indicators of course have been used in many studies on the carrying capacity of destinations, but often with little capability of making clear empirically changes that may have been achieved by measures taken by public authorities. This requires having an integrated, multidimensional understanding of the system to be managed and sets of indicators that reliably reflect the interdependence of economic, social and environmental processes at the destination. Hence, the indicators used must be based on a coherent conceptual framework that allows for a systemic sustainability assessment and well-informed decision making and management (difficulties and progress in the development of such frameworks are described in Bell and Morse 1999, 2003; Bossel 1999; Moldan, Billharz and Matravers 1997).

A good example for the progress in the definition of indicators and guidance on how to apply them is the guidebook *Indicators of Sustainable Development for Tourism Destinations* of the United Nations' World Tourism Organization (WTO 2004b; see also WTO 2007a). The guidebook addresses over 40 sustainability issues (for example, including management of natural resources, preservation of cultural heritage, satisfaction of visitors and host communities, economic leakages) and suggests relevant indicators and measurement techniques for each issue. The publication also contains a procedure to develop destination-specific indicators, their use in tourism policy and planning processes, as well as applications in different destination types (e.g., coastal, urban, ecotourism, small communities). Also, many case studies are included that illustrate the application of indicator sets at different destinations.

Bottom-up approaches:

Observers of the proliferation of carrying capacity studies and indicator sets for sustainable tourism have noted that the impact of this work on policy change so far has been limited. This is understood to be due to lack of awareness

of sustainability issues, political unacceptability of many required actions, inadequate institutional responses and, of course, opposition from entrenched interests (cf. Bell and Morse 2003, 50). Indeed, given the fierce competition among destinations, there often may be much more interest by government and industry players in competitiveness indicators (e.g., accessibility, prizes, etc.).

Therefore, hard-pressed communities and sites in tourism destinations will often need to argue their case by establishing a local 'sustainability barometer', documenting negative impacts, carrying out questionnaire surveys, etc. and presenting suggestions on how to get a handle on negative local situations. Also involving professionals in participatory research and collaborative policy-making on local sustainability issues may be helpful (Gahin, Veleva and Hart 2003; Vernon et al. 2005).

The above paragraphs intentionally do not attempt to provide an evaluation of the research that has been carried out on sustainable tourism at heritage destinations. A scanning of bibliographies and journal abstracts made it clear that:

- most attention so far has been given to natural heritage sites (for example, the articles on such sites in the Journal of Sustainable Tourism);
- there of course are a number of relevant publications (for example, Callegari 2003 – coastal heritage; Glasson, Godfrey and Goodey 1995 – historic towns; Helmy and Cooper 2002 – archaeological sites; Nasser 2003 – urban heritage; and many more scattered in a number of volumes on heritage management);
- a review of the state-of-the art in 'sustainable heritage tourism' is missing and would, indeed, be very beneficial to have, particularly if it were conducted on a regular basis;
- probably a lack in comprehensive analysis based on a systemic and interdisciplinary perspective would be identified, and difficult to overcome.

Finally, some general considerations may be appropriate: A large part of tourism in Europe is motivated by having the opportunity to experience and enjoy cultural and natural heritage sites. Therefore, the sustainability of heritage sites in environmental, social and economic terms should be high on the agenda of policy-makers at all levels. While tourism is often seen to threaten heritage sites by unsustainable usage levels it also is important for their long-term viability. As the different purposes of heritage sites (preserve) and tourism organizations (exploit) will often be in conflict, mutual understanding, partnerships and cooperation for sustainability will probably be the best way for preparing the ground for acceptable tradeoffs and sustainable solutions.

11.7 Integrated approaches for historic towns and ICTs in the experience economy

Study results of Salzburg Research within the Hist.Urban project emphasize the importance of an integrated approach for creating a 'cultural city' environment which leverages the quality of life of the residents as well as the cultural tourism potential of small and medium-size historic towns (Geser 2007a, b).

One important framework that has been used in this study work is the so called 'experience economy', which puts a premium on the experiential value of goods and services that allow consumers to gain enriching and memorable experiences (Pine and Gilmore 1999; Schmitt 2003; Smith and Wheeler 2002). Today, strong emphasis is put on 'experiences', not only in tourism and other recreational activities, but related to all kinds of goods and services. Experience has become a core value of consumption because people want to lead more intensive and meaningful lives, they seek after emotions and meanings, and want to participate in activities in a more individual way (with respect to cultural participation in museums cf. Kotler 2003; Prentice 2001a).

There is an enormous growth in experience-rich leisure and travel offerings such as theme parks, experience travel packages, new types of shopping mall and themed retail centres, visitor centres of consumer product brands, etc. Historic towns and cultural heritage sites should be aware of this competition and develop an experiential positioning, i.e., define and create distinct experiential values for cultural tourists.

Due to the widespread borrowing of concepts that seem to be successful elsewhere, there is a considerable convergence in the strategies cities use in the development of their cultural assets. Instead of an innovative 'placemaking' that stimulates cultural creatives and attracts purposeful cultural tourists, the result is a growing number of rather sterile and inflexible cultural spaces. Typically these spaces reproduce stereotypic notions of culture and heritage and reinforce passive cultural consumption patterns. In order to stand out, historic towns should use a distinctiveness strategy to create a unique position and brand on the cultural tourism market.

Developing a high-quality cultural environment may also help small and medium-size historic towns to prevent being exploited by mass tourism which devalues historic sites, public spaces and other resources. This requires

fostering local businesses and skilled creative people who share a common understanding and responsibility for realizing such an environment within an integrated and sustainable urban development. Protecting the quality of life and work of the residents is vital for such a development.

11.7.1 Developing a rich and distinct 'cultural city' environment

The figure below illustrates that in developing a distinct, high-quality 'cultural city' environment, historic towns must combine in an integrated way several development strategies. They cannot solely count on the attraction value of their built cultural heritage and 'specific atmosphere', but should develop an experiential positioning that also builds on other unique features and existing regional strengths as well as innovative elements.

This is also important for fostering creativity and cooperation among regional stakeholders, retaining talented people, and attracting inward investment of new businesses. The revitalization strategies should benefit the residents, local businesses and visitors, and are to be addressed with different measures and at different levels of intensity. Several of them do not need much public funding, but do need municipal governance.

The Figure provides an illustration of an experiential positioning, which should not be understood as the optimal solution for any historic town. Rather a town must develop such a solution taking into account its specific situation and local/regional conditions that will enable or inhibit the realization of certain experiential values.

In order to develop a distinct positioning the stakeholders will need to exemplify a considerable level of boldness, conceive of an integrated, longer-term strategy, backed up with feasibility assessments of critical components. Major threats along the way can be inability to foster co-operation among stakeholders or to create and sustain the required momentum. Also there may be a tendency to focus primarily on the 'cultural hardware' (e.g., built heritage, a new museum, etc.) and neglect the 'software' such as a creative cultural programme and events. As always there will be tight budgets, which, however, make their strategic use all the more important.

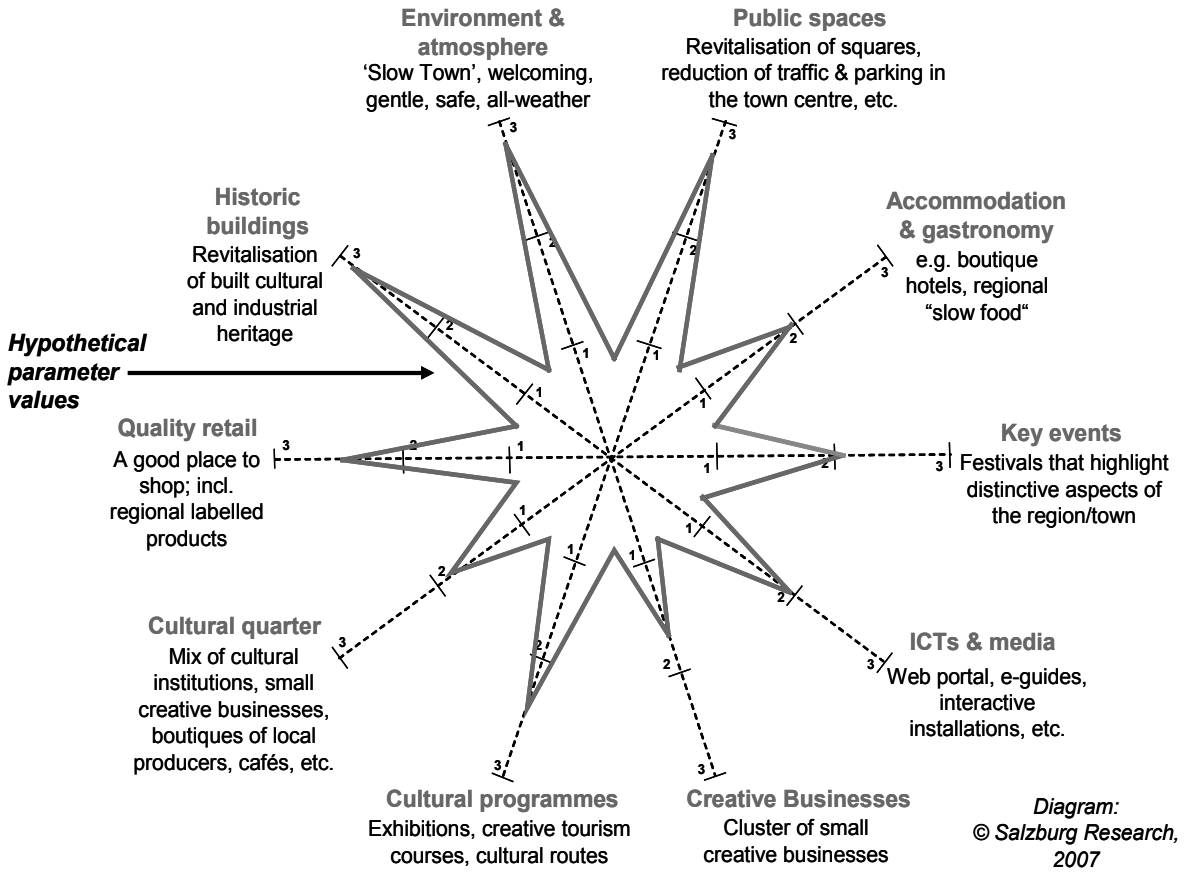


Figure 11.8: Example of an experiential positioning of a historic town

11.7.2 Development strategies with limited affinity to ICTs and online media

The figure above shows a large number of strategies for a 'cultural city' environment. In this section we summarize strategies which have only limited affinity to ICTs and online media (though, in the following paragraphs some relevant uses of generic ICT also are noted).

Built cultural heritage:
Well-preserved built cultural heritage of course is a major asset of a historic town. Investments in this asset should add to the revitalization of the fabric of civic, cultural and economic life in the town. Such investments will often require finding new uses of historic buildings that allow for a return on investment (e.g., higher prices of office spaces than those in a new building). Also industrial heritage buildings (e.g., production facilities, storehouses, etc.) in a peripheral quarter should be considered for such revitalization projects. If carried out properly there is a strong economic case for regenerating historic buildings in relation not only to the actual buildings but also to the wider area and the community. This is due to the fact that such buildings have multiple layers of value comprising historic character, architectural distinctiveness, local identity and colour, prestige of ownership, etc (cf. Drivers Jonas et al. 2006; this 'toolkit report' provides guidance in integrating the regeneration of heritage buildings into urban revitalization schemes).

'Slow town' approach:
Historic towns should aim at being 'slow' gentle places that emphasize quality of life and local specificities that allow for avoiding the 'sameness' that has afflicted many urban centres. This also is a counter-strategy to the large cultural cities that market themselves as vibrant places of cultural production and consumption. The 'slow town' approach has been developed and promoted by the Cittaslow initiative, which started in 1999 in Italy (http://www.cittaslow.net). The initiative provides a certification mechanism for towns whose population should not exceed 50,000: candidate towns must sign up to a seven-point plan, covering everything from good eating to the quality of hospitality facilities and the state of the urban fabric. Most Cittaslow towns are located in Italy, though there are also such towns in Germany (Hersbruck, Waldkirch und Überlingen), Norway (Levanger and Sokndal) and the UK (Aylsham, Diss and Ludlow).

Creative cultural programmes:
Such programmes cater for people's growing thirst for self-development, which is one of the most important drivers of the interest in creative tourism. Such programmes can comprise courses in restoration work, music, cooking/culinary culture, handicrafts workshops with local producers etc. (for many other examples see http://www.creativebreaks.co.uk). They do not require much investment, but allow for using creative competences and skills of local people, which will give them "more of a stake in tourism, becoming active producers of tourism experiences, rather than extras in a show of staged authenticity" (Richards and Wilson 2006, 1216). The slow pace and reassuring environment of a historic town and its surrounding will fit particularly well with creative cultural programmes. Yet, such programmes must relate to important local and regional cultural themes, i.e., there should be specific reasons for cultural tourists to engage in specific creative activities in the town. In economic terms, creative cultural tourists will stay longer in the town, e.g., an extended weekend, whole week or even longer, depending on the type of courses and other activities offered.

Connecting with the wider region and natural surrounding:
For tourism in large cultural cities the wider region and natural surroundings are not relevant in most cases. However, for smaller historic towns it will be crucial to emphasize the regional embeddedness of the town with respect to cultural as well as ecological aspects. This is important with respect to visitors who prefer to stay in the countryside (e.g., for cycling, hiking, golfing, wellness etc.) but will also take the opportunity to visit the town. The intention to combine these activities will often be an important factor in the decision to visit the region. For overcrowded historic towns developing attractive cultural and other leisure places in the surrounding may also help in achieving a better distribution of tourists and additional income. 'Cultural gateways', both physical and virtual, may help connecting the cultural heritage of peripheral communities to existing tourist value chains (cf. Russo 2005, who reports on 'gateway' projects in Catalan and the Galician destinations in Spain and the Veneto Region in Italy).

Fostering creative businesses:
Availability of creative, highly skilled people is a precondition for a competitive and innovative region, city or town. Yet talented people must receive support in developing local creative businesses, e.g., through making available affordable office spaces with appropriate infrastructure. State-of-the-art ICT infrastructure and high-bandwidth Internet connection may be of particular importance for creative businesses and a cultural quarter (see below). However, it should be noted that companies who emerge from creative industry initiatives typically are small service companies (up to 10 employees, but more likely micro-businesses) in fields such as media, software, visual arts, design, fashion, etc. (cf. Wiesand and Söndermann 2005).

Cultural quarter strategy:
A medium-size historic town should also consider developing a cultural quarter (for discussion of the cultural quarter or cluster concept see Mommaas 2004; Santagata 2006). This requires pooling, supporting and stimulating synergies between a variety of cultural, creative, shopping and leisure resources. The result should be an attractive and dynamic mix of cultural institutions, small creative businesses, boutiques of local producers, cafés, restaurants, etc. Ideally the cultural quarter strategy is used to revitalize an area of the town and aims at creating a quarter and street life that is attractive also for cultural and creative tourists. Within the town the availability of Internet access points or a larger Wireless Local Area Network, which can be freely used by residents and tourists, can add to the town's image of openness and creative revitalization.

Key events that reinforce longer-term strategic development:
Key events such as festivals should highlight and reflect aspects that are distinctive for the town and wider region. They should also be linked up with and reinforce longer-term activities. Because they can act as additional engines to create momentum, involve a wider group of stakeholders and sponsors, infuse expertise and know-how from invited professionals, and leverage the attention and interest of the media for the town. Rather than an approach of 'something for everybody', key events such as festivals should be thematically focused and build on a critical mass of related regional activity. This is more likely to be widely acclaimed by the media than cultural imports from elsewhere that have no tangible basis in the region (cf. Rutten 2006, 48–49).

Quality accommodation and gastronomy:
Historic towns should also foster the development of hotels that have a unique style and charm, e.g., 'boutique hotels' in buildings with historic character. For example, Malta has launched a programme for developing small boutique hotels in the historic city of La Valette. Regarding the gastronomy in historic towns, the concept of 'slow food' will be particularly worthwhile to consider. Rather than repeating the typical formulas of 'traditional food' and 'local recipes' it is important to emphasize the creative reinterpretation of the regional cuisine by a gastronomy that is focused on quality and hospitality.

Quality retail development:
A historic town will benefit from a clear-cut retail development strategy that allows for becoming 'a good place to shop'. Such a strategy should foster quality retailers and shops of regional producers rather than standardized stores of large retail chains (approaches and case studies of retail development in historic areas are presented in English Heritage 2005b). The strategy may also include limiting, at important places of interest, the number of typical souvenir shops or, worse, temporary outlets of low-quality, cheap goods that have no relationship whatsoever with the town .

Labelled products inspired by regional cultural heritage:
There may also be an opportunity to develop and promote products of creative craftsmanship and artistic skills that are inspired by regional cultural heritage (e.g., shapes, colours, materials, etc. of historic ceramics, glassware, dress or furniture). For such products a label may be established and marketed which gives an incentive to high quality and helps in protecting and distinguishing local/regional products from the assortment of cheap imported products that are usually sold at tourist places (Russo, Santagata and Ghafele 2005).

11.7.3 Communicating the experiential benefits of historic towns with ICTs and online media

ICTs and online media form only one component of strategic development among many, although it is clear that they can help a historic town gain competitive advantage in several ways. These are summarized in the following paragraphs with a focus on the particular challenges of communicating the experiential benefits of a historic town.

As the Research Agenda concentrates on research needed to realize the potential of ICT support to the tasks and content of cultural heritage organizations and related stakeholders, we do not address applications for online booking, ticketing and purchasing, which may be realized with novel dynamic packaging solutions.

High challenge of communicating experiential benefits:
The first point to note with respect to ICT-based communication is that the communication should concentrate on the experiential benefits a historic town (or other cultural heritage site) offers, because these benefits are what will make people want to actually visit the town. Communicating the experiential benefits is not easy, because the potential visitors will gain them only when actually visiting the town.

Therefore, the town together with individual service providers (e.g., a cultural quarter, hotels, restaurants, etc.) must communicate the unique experiences they provide in a way that allows the visitor to recognize beforehand and anticipate these experiences. Customers today want to have 'success guaranteed' before they actually buy a product or service. This is relatively easy with standardized and primarily functional products or services, but not with products and services that are marketed based on their experiential value.

This applies to all cultural tourism offerings. For example, Deborah Hayes and Nicola MacLeod (2007) analysed heritage trails brochures and leaflets against a set of principles of experience design. They found that while such material starts positioning trails as experiences (rather than products) there is still considerable scope for improvement (Hayes and MacLeod 2007; see also Voase 2007, who analysed the promotional and interpretive information for visiting a cathedral).

State-of-the-art dynamic Web sites and Web portal:
With respect to the development options addressed above, state-of-the-art Web sites of individual historic buildings and monuments, events, creative cultural courses, local producers, quality retailers, gastronomy, etc., with carefully chosen visuals and messages, will be used. Integrated in a dynamic Web portal they will play an important role in mediating the many experiential values of the town.

Web sites that allow visitors to find and explore convincing experiential value propositions should be used rather than a product-driven approach focused on the typical travel package. Multi-lingual content will be required, at least for the main visitor segments. While a rich Web portal can be a gateway to a virtual visit of the historic town, care must be taken that people do not get lost in a multitude of sub-pages; logging data can provide information on what works as well as points where visitors get lost.

More advanced Web solutions could provide a true 'online stage' for pre-visit interactive communication of experiential benefits. This may be realized through a dynamic creation of experience profiles/segments of the town (e.g., cultural places) according to the specific interest of online visitors. Also, a 3D virtual environment with different 'rooms' could be used.

Participation of local people and institutions:
Historic towns may find it difficult to communicate the cultural richness and regional importance of the town beyond its function as an 'attraction value' or 'brand asset'. Rather than a typical marketing strategy, a distinct approach is to involve local people in the communication of cultural experiences and place-specific cultural contexts. Besides the expertise of archivists, curators and site managers, also personal voices of people who live and work in the town can communicate to potential visitors the specificity of the town, particular places and activities such as local events. This may create an emotional resonance and first personal attachment for visitors with the town, its people and places.

Visitors' own images and stories:
Strongly related to people's quest for experiences and self-fulfilment is the increasing use of new digital tools for documenting one's own way of life. Ever more people capture images (photographs and videos) of leisure and travel activities using digital cameras. Many place them on online content Web sites and sharing services such as Flickr or YouTube, which have seen tremendous growth in user-created content. More and more people also express their own ideas using Web-based tools such as Weblogs. (Note: more information on these trends and their relevance for CH institutions is to be found in section 8.4).

Historic towns and other cultural heritage sites may benefit from fostering online communities of people who share an interest in the town and region. Images and stories of visitors, including testimonials, could greatly enhance the vibrancy of a historic town's online portal or, more likely, a related Web site. Furthermore, user-

created content may provide clues for enhancement of experiential value and visitor management. However, for most towns and cultural heritage sites the challenge will first be to embrace the idea of co-operating with a (non-professional) online community, and then to nurture an evolving and thriving community that crosses the virtual as well as the physical space.

Cultural routes:
Cultural routes can attract tourism to a region and important nodes such as historic towns. They can also be used to link up the town with interesting places in the surrounding area. Yet there is doubt about whether cultural routes work for a 'network' of historic towns that are widely distributed in a region or country. For example, in the Netherlands five historic towns – Haarlem, Leiden, Delft, Dordrecht and Schiedam – were linked in a promotional campaign 'The Secret of Holland'. This project was stopped after four years. The perceived resemblance between the towns limited tourists' interest to visiting no more than one or two of the towns (cf. WTO – World Tourism Organization and European Travel Commission 2005, 48).

In the last two decades there has been a boom in cultural routes ranging from major routes that are acknowledged under the cultural routes programme of the Council of Europe (started in 1987) to many lesser known regional routes that have been developed for capturing tourist interest. However, little is known about the effectiveness of cultural routes for attracting and retaining tourists and the role ICT applications play in this (Owen, Buhalis and Pletinckx 2004 present a framework of the information requirements visitors may have).

Marketing platforms of historic towns:
Bringing together historic towns can make sense if the goal is to create a platform for joint marketing, e.g., production and distribution of marketing material. Examples of such a cooperation of larger historic towns are 'Historic Highlights of Germany' (http://www.historicgermany.com), which has 13 participants, and, in Austria, 'Kleine historische Städte' – a marketing platform of 18 small historic towns (http://www.khs.info).

There are also other marketing platforms that historic towns can use if they have implemented certain products or services. For example, Europeancitycards.com is a Web site where one can buy city cards from 43 cities in Europe; among the smaller cities, for example, are Dubrovnik, Innsbruck, Nürnberg, Salzburg and York. Europeancitycards.com works in association with European Cities Tourism, the network of European Tourist Boards.

Electronic tour guides:
Electronic tour guides are an interesting exploration opportunity for historic towns (Ross et al. 2004, 91–118; 2005, 153–182, the latter providing an overview on the application of mobile and location-based systems in the cultural heritage sector). Electronic guides typically offer visitors different thematic entry points and suggestions for walking tours around the town with information about places and objects, what to look for specifically, etc. Electronic tour guides will also, or even more so, be important if historic towns integrate into their tourism programme attractions and routes in the wider area. The opportunity for visitors to capture and share content (e.g., URLs) with mobile devices could also help promote the town and region to others. (Note: more information on trends, projects and recommendations concerning mobile electronic guides is to be found in sections 6.9 and 8.3).

Ambient intelligence environments:
A field of future ICT applications for experiential benefits is ambient intelligence environments. Such environments will comprise wireless, sensor and other technologies for seamless outdoor–indoor communication with location-based, user context-aware information services, not only for historical information, but also for promotions, e.g., retail or events. Personalized virtual tour guides would be capable of appearing on the screen of any interaction device, e.g., mobile, outdoor displays, shop windows, etc. Information would be provided and stories told according to thematic interest in streets, squares, buildings and other locations, and visitors and locals be invited into buildings or to provide own digital images of and comments about the town. (Note: more information on such applications is to be found in sections 5.3 and 6.9).

11.7.4 ICT-based applications for on-site presentation and interaction

In many publications it is claimed that ICT-based applications for on-site presentation and interaction (e.g., in museums, visitor centres of heritage sites, monuments, etc.) can greatly enhance the cultural experiences and knowledge acquisition of visitors. Yet, such applications often have only the role of an 'add on', which is not

fully used by visitors (in contrast, for example, to science centres, where virtual reality and simulations have become a core element of presentation and visitor interaction). For example, an exploratory visitor survey at five outstanding UK heritage sites, museums, monuments and archaeological sites that have implemented different ICT applications concluded that all of the applications "were found to be underutilized" (Owen, Buhalis and Pletinckx 2005). Unfortunately, very little is known about the total cost of ownership of such applications compared with their attraction value and experiential benefit for visitors.

What is clear, though, is that ICT applications for on-site presentation and interaction must fulfil many requirements. In particular, they should be:

- easy to use and understand, engaging and inspiring, allowing visitors easily to learn about the heritage site and artefacts;
- based on advanced technology and high-quality content, but mature and stable;
- manageable by the site's staff, who cannot be expected to have experience in computer programming;
- furthermore, with a view on a wider adoption in the sector, ICT applications should be deployable in different environments and available in a range of costs.

What also must be recognized is that the visitors will become increasingly demanding. The visitors' measures with respect to ICTs and media experiences are set by leisure and entertainment offerings that often are created by teams of highly skilled professionals with large budgets. As BRC Imagination Arts, an entertainment development company that also works with heritage organizations, write on their Web site: "While guests expect accuracy – be it historical, scientific, technological, and/or cultural – their measure of entertainment value has been set by theme parks, film, television and the Internet. And unfortunately, less public money is also available for cultural venues. This forces institutions to compete for guests' leisure-time and money to supplement funding" (http://www.brcweb.com/education).

Therefore, heritage sites will need to concentrate on enhancing the experiences of visitors and imparting cultural knowledge in novel ways that involve the visitors. This is not an argument for turning cultural heritage sites into entertainment venues but a warning that offerings that do not invite, inspire, engage or immerse will not find a wider appeal. An impression of what others are offering can be acquired by scanning the programmes of the recent TiLE conferences. TiLE is a major forum for leisure venues and visitor attractions. This comprises theme parks, science centres, planetariums, aquariums, museums and other cultural institutions. Some on-site applications that are presented at TiLE events include audiovisual technologies, multimedia, animatronics, simulation and virtual reality (http://www.tileweb.org).

11.7.5 Applications for experiential positioning, planning and development

ICTs will also play an increasingly important role in urban planning and development. INTELCITY, a one-year roadmap project under the FP5-IST programme, explored opportunities in this field and published interesting results that relate a range of ICT tools and services to urban planning and development processes (INTELCITY Web site). For example, it is clear that a large part of municipal planning tasks can be supported by geo-spatial information and GIS applications, which will also increasingly allow for understanding better environmental, economic and socio-cultural dynamics. There are also many IT-based tools that can be used in 'placemaking' projects with local communities (cf. the overview in CONCERN 2002).

Particularly interesting would be applications that support experiential positioning, planning and development, including stakeholder participation. Such applications could support development tasks such as asset identification, trends and competitor analysis, and definition of a distinctiveness strategy (e.g., based on an 'experiential benefits SWOT' of a town). Furthermore, predictive modelling, simulation and analysis tools, including analysis of potential impacts and calculators for investment plans and return on investment for stakeholders would be of interest.

Town-level experience design could be used to define the potential experiences at certain places, including interaction modes and content. A particular goal of such a design may be to develop new experience spaces to move visitors away from overcrowded areas. One form of access, presentation and interaction could be a GIS layer of experience places, interaction modes, and geo-referenced multimedia content of museums, historic buildings, events, cultural courses, quality retailers, gastronomy, etc. The design and realization of the town's experience landscape could also provide an opportunity for local/regional creative businesses.

12 Synthesis of recommendations

12.1 Recap on the context and purpose of the Research Agenda

EPOCH – Excellence in Processing Open Cultural Heritage – has been a Network of Excellence co-funded under the European Union's Sixth Framework Programme, Priority 2, Information Society Technologies. EPOCH involved 95 partners from a wide range of perspectives, brought together to create a holistic view of the field, integrating and enhancing the previously fragmented efforts in research directed toward intelligent information and communication technologies (ICT) for tangible cultural heritage. The target for these technologies is monuments, site and museums and the collections of tangible heritage that they hold. Monuments and sites include castles, churches, monasteries, historic town centres, archaeological and other heritage sites.

The Research Agenda is a distillation of debates and expert opinions on necessary future directions that have taken place both within the Network and beyond as this very interdisciplinary group has shared a journey over increasing cross-fertilisation of ideas and perspectives and engaged others in the debates.

EPOCH was founded on a basis of taking the holistic view of the field. As well as ICT researchers, the Network includes researchers in cultural economics, arts and humanities, social studies of cultural participation, cultural administration, regional regeneration and many other relevant fields of research-based guidance of policy making and professional work in the cultural heritage sector.

This multi- and inter-disciplinarity is required to fully address the goals set by the European Union in the **Lisbon Agenda** to make the European knowledge society competitive in sustainable economic growth and employment and a good place to invest, live and work based on a high quality of life.

Europe's rich and diverse cultural heritage makes considerable contributions to the Lisbon Agenda. Cultural landscapes, historic towns, museums, monuments and other heritage sites benefit the European tourism sector, heritage sites and museums show considerable multiplier effects in employment (one job in cultural heritage generating between five and nine in related sectors), they drive citizens' cultural learning and enjoyment, and also they contribute in many other ways to the quality of life and regeneration of European regions and towns.

ICT applications and digital content already add considerably to these societal benefits and there is much more to expect from new and enhanced technological capability. This expectation motivates dedicated funding of collaborative research projects under the **7th Framework Programme** (e.g., the ICT Challenge 'Digital Libraries and Content') and the flagship project of a **European Digital Library** under the i2010 Information Society focus Digital Libraries.

Yet there is much to do to deliver the potential benefits. EPOCH's effort to provide a common research agenda in cultural heritage and ICT is intended to foster a better cohesion of the communities involved, promote synergies among new initiatives and projects, yield more efficient spending of available funding, and result in better and more sustainable ICT based solutions.

The following sections make recommendations in distinct but related components of this holistic perspective.

Group: 1 Embedding interdisciplinarity

This group of recommendations seeks to set the context which will foster the inter-disciplinarity for research to be of most relevance and have most impact. Together they will encourage the best researchers to engage in the field, enable better projects to be supported and, in the long term, encourage young researchers to enter the field, bringing inter-disciplinarity built-in from their training.

Recommendation: 1.1 Recognise and value the real benefits of use-inspired basic research in ICTs for cultural heritage applications

Use-inspired basic research is none-the-less basic research and as such will take time to mature to deployable applications. It should be appreciated that research of this type can increase understanding of basic issues in ICT and, at the same time, provide the basis for new or enhanced applications for cultural heritage, a particularly demanding field for testing assumptions, concepts and prototypes.

Recommendation: 1.2 Foster a higher degree of inter-disciplinary research and development

Inter-disciplinarity is key to promoting highly relevant research, drawing on theories, methods and results of other disciplines such as, geosciences, cognitive sciences, linguistics, archaeology, humanities, and others. Consultation and user requirements specification is no substitute for close inter-disciplinary working between ICT and cultural heritage professionals. More infusion of cultural heritage domain expertise may also raise the likelihood of successful knowledge transfer and development of research proofs of concept to market ready solutions and wider adoption by the sector.

The 'Two Chasms' model highlights the difficulty for 'end users' to engage in basic research in ICTs – you need users with long-term perspectives, lots of altruistic patience and very broad understanding of the research process, who commit to deep engagement in the research. Polling of external opinions without careful selection can rarely inform or influence basic research directions.

Recommendation: 1.3 Undertake ontological modelling and systematic, empirically-based analysis from disciplines in which intelligent applications are intended to work

Basic research projects normally demonstrate their success through proof of concept implementations covering a restricted part of the domain. To create useful tools their applicability needs to be extended to the whole target domain. This recommendation would establish a broader base of domain knowledge which is systematically encoded and could be used to underpin this process. The existence of this base, once established, could also be used in future basic research projects to ensure that the proof-of-concept phase was also well founded.

Such work comprises, but is not limited to, ontological modelling of domains of knowledge and systematic, empirically based analysis. For example, a comprehensive formal ontology of the geospatial domain would allow geospatial information to be represented and processed across different levels of scale and granularity and thereby considerably leverage the capability of GIS applications. Systematic analysis of architectural design styles is required to develop rules for grammar-based procedural 3D modelling. Empirical knowledge about human cognition of space, qualitative spatial reasoning, relationships between natural language and representations of space, etc. could underpin enhanced location-aware services. In short, a lot of potential could remain untapped if such research empowering ICT applications with new or enhanced capability is not considered properly.

Recommendation: 1.4 Promote research that builds in CH operational and user situations

Research in ICT applications that contextualises CH operational and user situations should be given priority. Research should be influenced at prototype development stage by expertise in envisaged contexts of use, likely organizational impact, implied training requirements, usability and user experience. Often this will be decisive if proposed new systems are to be successful with cultural heritage institutions and end-users. For example, in highly distributed applications, context-aware computing, and novel types of user interface, experience prototyping rather than classical user requirements and usability engineering is likely to be most successful.

Recommendation: 1.5 Disseminate and share research results using approaches which are effective for the CH sector

Initiatives to promote progress in RTD for applications of ICT to cultural heritage should consider the most effective approaches of disseminating and sharing results. Adherence to principles of Open Access to research data and publications as well as Open Source software generally will help make results of research work more readily available and allow for a better valorisation of investment. In particular, if research work is fully or to a larger part publicly funded researchers should follow these principles. Open Source software will allow not only for re-using software among developer communities, but for potentially extensible and more sustainable CH ICT applications. The interests of CH institutions in their data might be addressed through 'not-for-profit' conditions of use.

Recommendation: 1.6 Support the development of European Research Infrastructures that are of relevance to research in cultural heritage ICT applications

In October 2006 the European Strategic Forum on Research Infrastructures published the European Roadmap for Research Infrastructures, which documents suggested new and major upgrades of existing research infrastructures. Some of the 35 projects (facilities, research equipment, databases, and networks) are relevant to R&D projects in CH ICT, in particular, those with a focus on social sciences and humanities. Research centres should be encouraged to support their development or propose additional 'e-infrastructure' projects to make available advanced applications specifically for the European R&D community in CH ICT.

Recommendation: 1.7 Leverage the offer of CH ICT programmes and courses in tertiary education and training as well as opportunities for mobility of young researchers

The future supply of inter-disciplinary researchers will be greatly enhanced by availability of CH ICT-related university programmes allowing specialization in the field, but there is little available research-led teaching in CH ICT and there are few institutions offering M.Sc. or Ph.D. qualifications in cultural informatics. European Masters degree programmes with a focus on CH ICT would be particularly welcome as well as measures to encourage individual universities.

This should be complemented with more opportunities for mobility (both geographic and disciplinary) of young researchers in this field. For example, funding available under the 'People' strand of the 7th Framework Programme, e.g., for Marie Curie actions, could be used for opportunities similar to those in the current CHIRON Early Stage Training project.

Group: 2 Cultural heritage ICT technical research

This group of recommendations identifies short-, medium- and longer-term technical research priorities in the fields of research that have been priorities within EPOCH. For example, when it comes to topics in the preservation and curation of digitized and born-digital cultural resources, the more general aspects are addressed by the research roadmap of the FP6-IST coordination action DigitalPreservationEurope. Here recommendations would address only those aspects that are specific to content where EPOCH had other interests from the processing perspective. 3D content has been a specific concern for EPOCH and a specific sub-section of priorities and recommendations addresses this.

Group: 2.1 RTD for 3D content

3D artefacts and environments are an important part of (digital) cultural heritage, because perceived reality *is* in 3D. The impact of 3D content in the field of cultural heritage is expected to be high, as such content, for example, allows for presenting rare and fragile (and maybe 'repatriated') museum artefacts as well as very large objects (e.g., virtually reconstructed heritage sites and buildings). Moreover, 3D objects offer more potential for interactivity since they can be observed and manipulated from different viewpoints, for instance.

Interest in 3D data acquisition for purposes of documentation, research, virtual reconstruction and presentation is widening. The creation of physical replicas of CH objects (e.g., busts or statues), archaeological artefacts (e.g., carvings) or human remains is also attracting more interest. More and more 3D data will be captured and used for other tasks, for example, as part of regional development planning which includes preservation of cultural heritage sites.

Creating 3D assets involves very different tasks from those for the acquisition of 2D images and applications using them often require a critical mass to be available to realize the potential value added. Digitization normally needs to take place on-site and non-textual metadata needs to be integrated for effective management, search and retrieval, and other 3D data processing. Current tools are still inadequate for capturing some classes of artefact. There are therefore many challenges in creating a 'critical mass' of high-quality 3D content. Thus the efforts in the EDL initiative to build large-scale digital libraries of cultural heritage have not so far given priority to acquiring 3D assets.

Recommendation: 2.1 Advance the state of the art in 3D-digitization tools for 3D shape, surface type and material acquisition, investigating both active and passive acquisition methods and improving the range of artefacts that can be captured at reasonable cost

There are classes of artefact where 3D asset capture is still an unsolved research problem, often affecting classes of particular heritage interest (e.g., optically complex objects such as jewellery or glass, and non-rigid soft materials such as costume). In addition available technologies need improvement to achieve affordable high-quality, standardized and flexible technologies for 3D data capture and allow for wider adoption.

Recommendation: 2.2 Develop tools for the integrated management of the metadata related to 3D artefacts

The capture of shape and surface properties is only part of the task of creating 3D digital artefacts. To complete these requires association with metadata (including the traditional metadata that might form part of the museum collection documentation). There are specific aspects of this metadata that are unique to the digital domain including the digital artefact structure and parameters, the relationship of the digital artefact to the physical artefact

(e.g., coordinate systems and metrics); the digital provenance (i.e., techniques employed to capture primary data, processes used to create the model from the primary data, tools and parameters employed, etc.). The digital provenance is a vital part of the long-term usability of the digital artefact providing information for migration to new formats in the future.

These tools would draw extensively on the ontological framework developed under Recommendation 1.3.

Recommendation: 2.3 Develop tools for the analysis of 3D artefacts and associated information

Tools are also required to analyse higher-level semantics of shape, documenting the description and semantic classification of the modelled objects, their parts and employed analogies, the design styles, location, history, and cultural–historical associations. As analysis is built over time the metadata structure and underpinning ontology will include links to other sources and expert annotations about modelling assumptions and related cultural–historical data. Additional tools will assist the CH professional in resolving co-referencing (different references to the same sources in other documentation), to conduct shape and material similarity searches and to link text source references to the artefacts to which they refer.

Recommendation: 2.4 Develop intelligent tools for 3D acquisition

An important way to substantially reduce the time, effort and costs of 3D acquisition in the long term is to create intelligent tools which will simplify the processes and reduce the level of ICT skills needed to undertake the tasks. This can be done by developing methods and tools which allow the operator to undertake the tasks based on working practices in the application domain, rather than becoming an ICT expert in order to be able to operate tools that intrinsically feel alien to them. For example in 3D scanning and photogrammetry, a core problem in 3D data manipulation is at present merging multiple raw scans and smoothing. This is undoubtedly difficult operationally, but the development of tools that make this operation semi-automatic and user-friendly is a more sustainable approach than to alter the working practices and educational background of all Cultural Heritage professionals to accommodate these processes. At present this would normally be undertaken by the engagement of specialists for the 3D digitization campaign.

Longer-term improvements should be targeted at producing more intelligent instruments (e.g., to incorporate knowledge of, and capability for recognition of object classes and adaptation of their *modus operandi* to optimally handle them).

Recommendation: 2.5 Exploit the opportunities provided by procedural modelling

New developments in procedural modelling hold great promise for cultural heritage for modelling and visualising reconstructions of architectural, decorative and other styles of man-made artefacts. In particular, compact representation of very large models of urban environments can be achieved with this technique. Based on grammatical and parametrical descriptions of shapes (for instance of the architectural style of buildings for a targeted period) models consistent with these descriptions can be produced quickly and at low cost. As a result, large-scale modelling projects can be undertaken, as already exemplified through EPOCH's 3D model for the entire Area 6 of the Pompeii site.

Moreover, the ability to produce massive models efficiently opens up the opportunity to do so multiple times with parametrically controlled ranges of variation. This offers new ways of expressing degrees of uncertainty about the virtual reconstructions.

Architecture was taken as a good case in point, but procedural modelling should be seen as a paradigm with generic potential for any type of objects that are structured according to some kind of 'rules', be it natural, as in certain fossil types in palaeontology, or man-made design styles, such as art nouveau vases in art history.

Recommendation: 2.6 Develop easy-to-use authoring tools for 3D experiences

Digitizing tangible cultural heritage objects in 3D format is only a first step towards 3D experiences for end-users. The creation of complex 3D environments for end-user interaction will usually require the involvement of specialised companies. But, it would be beneficial to provide museum curators, archaeologists and other CH professionals with an easy-to-use toolkit that interfaces to standardized repositories and allows the authoring of 3D multimedia presentations with limited effort. For example, the authoring tool could support visualization of a site as it evolved over time, distinguishing between fact and interpretation (including perhaps the evidence/rationale to the hypothesis).

Recommendation: 2.7 Promote adherence to the principles of the London Charter for the Use of 3D Visualization in the Research and Communication of Cultural Heritage

There is an increased awareness of the importance of ensuring both that 3D visualization methods are applied with scholarly rigour, and that the visualizations accurately convey to users distinctions between evidence and hypothesis, and between different levels of probability (e.g., in the 3D reconstruction of heritage sites). This has been addressed in the London Charter (http://www.londoncharter.org), which aims at establishing internationally-recognized principles for the use of 3D visualization by researchers, educators and cultural heritage organizations. The methodological and other principles for integrity, transparency and quality, as well as community in 3D visualization, should be adopted and consistently used by subject communities and other stakeholders in the CH sector.

Recommendation: 2.8 Develop solutions for improved search, identification, re-use and integration of 3D datasets by end-users

There is a need to better support the end user in identifying and re-using 3D digital assets. Search and retrieval will be used in a variety of contexts with differing priorities in terms of the search criteria. In particular, there are shortcomings in the effective integration of 3D datasets from different sources within the context of analysis, interpretation and presentation. For example, desktop GIS should allow for making more easily available datasets in an integrated fashion for researchers and practitioners. In this context, it will be beneficial to support better the extraction of areas of potential interest from large data-sets. There are also still significant limitations for end-users in handling large file sizes (cf. the Big Data survey of the UK Archaeological Data Service) and it is likely that the extraction processes may also filter the underlying models.

Recommendation: 2.9 Provide solutions for effective rights management of 3D content

3D content will often integrate a number of 3D assets into an environment and, hence, be more difficult to manage than other content, such as individual images. With respect to such content CH institutions will worry about the capability for a proper handling of provenance data and IPR in the digital content. Therefore, effective solutions for the management of provenance data and rights clearing and licensing are of particular importance for achieving a wider use of 3D objects and environments.

Recommendation: 2.10 Ensure access to 3D content through the European Digital Library

The current European Digital Library initiative does not fully recognise the importance of 3D content for presenting and providing access to digital surrogates of the extremely rich but dispersed physical cultural heritage such as museum artefacts, monuments, historic buildings and other objects of the historic environment, archaeological and other heritage sites across Europe. In a conservative estimate, there have been in the last 10 years some hundreds of 3D digitization projects carried out or commissioned by public or private owners of built heritage across Europe. For a start, an overview of completed and ongoing projects should be created (see also recommendation 3.1). This research should establish the technical basis for guaranteeing interoperability over the rich functionality required for 3D digital assets. One goal of this work should be to investigate the possibility of migrating existing 3D content through a common trusted repository related to the EDL initiative.

Recommendation: 2.11 Aim at non-textual, semantic documentation and processing of 3D content

With the growth in 3D content there is a pressing need for progress in the field of semantic processing of such content. This would allow for getting past the limitations which current data capture and encoding techniques place on what digital libraries can support with respect to 3D digital object libraries.

The current development of metadata, including the semantic Web approach, is primarily text-based, which has considerable limitations when it comes to 3D content. Indeed, adequate 'vocabularies' to characterize the content and structure of 3D objects would be non-textual. Development of such vocabularies and ontologies is key to 3D content categorization, indexing, detailed search and retrieval (e.g., for parts of heritage buildings or statues), and enhanced access through digital libraries.

The important breakthroughs will need to be based on developing the understanding of the higher dimension semantic relationships that we seek to represent, many of which are intrinsic in human understanding but not established, documented, shared consistently and agreed. Only when this work is tackled will we be able to overcome the current treatment of 3D objects in digital libraries as BLOBs (Binary Large Objects) and generalized documents.

Among the groundwork needed to allow for effective digital library support of 3D content are: definition of a sustainable 3D file format; generic, stable, and detailed 3D markup; automatic 3D content organization and search and retrieval capabilities. To this end, catalogues of semantic 3D features will need to be defined and shape analysis algorithms designed for their robust detection in 3D content.

Group: 2.2 Specific RTD for site-based systems

There are many negative impacts on natural and cultural heritage sites, standing heritage structures and subsurface archaeological sites because of environmental, economic and social factors, in particular, global climate change and regional and cross-border infrastructural development. Enhanced or new ICT applications could help to monitor and limit damage of cultural heritage. In general, more effective cultural heritage management systems and integrated online availability of information can help administrators, planners and contractors to take well-informed decisions that reduce unfavourable impacts on the cultural environment as well as allow for working more cost-effectively.

The increasing need of monitoring, risk assessment and proactive damage prevention has made the capability to integrate, process, visualise and analyse data sources a matter of urgency. This requires considerable improvement in the access to, and interoperability of, relevant data sources. Such sources for enhanced heritage management systems could come from:

- mobile, GPS handheld tools that are used in field surveys and archaeological excavation work;
- ground based remote sensing, e.g., from in-situ sensor networks that provide spatially and temporally referenced streams of data;
– remote, satellite and aerial sensor data and imagery (e.g., hyperspectral sensors, InSAR and LIDAR technology).

Often a combination of data from remote sensors, in-situ sensor networks and mobile tools will be required for optimal survey and documentation work and decision-making in specific situations. The following recommendations address research priorities that are understood to present short- to medium-term challenges.

Recommendation: 2.12 Leverage capability of mobile devices for field data collection

Field data collection with mobile devices should be leveraged through: consolidation of the current proliferation of 'home-grown' tools developed by many research groups, including the identification of innovative features; developing a standardized driver architecture for the latest generation of survey instruments and making more readily available APIs; improvements in the interoperability of recording tools, in particular of surveying and geophysical instruments.

Recommendation: 2.13 Develop highly effective, integrated ICT tools for rescue excavations

The required speed in the capture, collation, and creation of metadata for the heterogeneous data sources of rescue excavations necessitates more effective ICT support in the framework of a highly standardized excavation process. The ICT support should comprise:

– a robust system of hardware and software components that allows for wireless, mobile and Internet computing during field campaigns;
– high integration of the tools used on-site, e.g., coupling of GPS handheld devices with other equipment such as Total Station;
– parallel use of content upload to a central (on-site or remote) repository and metadata creation for the data sources (e.g., textual documentation and numeric data, topographical and stratigraphical data, photography, video and 3D data);
– tool support in the creation of descriptive data about finds (e.g., CIDOC Core Data Standard for Archaeological Objects), embedding this as close to the point of data collection as possible to reduce transcription errors;
– semi-automatic creation of structural metadata about the resources and their inter-relationships, e.g., METS (Metadata Encoding and Transmission Standard) documents;
– rapid integration of find data and geophysical data with maps, 3D stratigraphy and GIS layers, including different scales for structural analysis.

Recommendation: 2.14 Investigate the usefulness of sensor networks in CH monitoring

The monitoring of larger cultural heritage sites could benefit from making use of a variety of environmental sensors and novel networking technology. Sensors, operating systems and data processing devices are becoming smaller, more effective and cheaper, short-range radio applications are consuming less power, and multi-hop networks are expanding from small local to larger areas. This progress has opened up a range of options for using wireless technologies for real-time monitoring and analysing of environmental as well as visitor impact on cultural heritage sites and decision-making on preventive measures, though the opportunities have not been fully realized so far.

Recommendation: 2.15 Leverage GIS-based CH management through model-driven approaches

With respect to Geographic Information Systems, Web GIS applications are becoming the dominant form of working with ever more integrated data and services. However, most current generation GIS-based CH management systems are not equipped for purposes of real-time monitoring, risk assessment and decision-support for damage prevention. To realize such systems there is a need to get beyond the current 'data-to-layers' approach towards 'data-to-models' and 'data-to-decision'. With respect to environmental impact, this would require to develop appropriate dynamic simulation models as well as incorporating regular streams of relevant environmental data sources (e.g., from local sensor networks). Targeted research into model-driven approaches to cultural heritage management would also be beneficial with respect to proactive measures in regional development and tourism management.

Recommendation: 2.16 Cultural heritage organizations should engage in the development of European spatial information and monitoring systems

Cultural heritage management organizations will need to be involved in the current development of European information infrastructures to ensure that specific needs of CH are taken into account.

Access to and interoperability of geo-referenced CH information could become an important component in the European Union's Infrastructure for Spatial Information in the European Community (INSPIRE) initiative. The Directive of the European Parliament and of the Council of 14 March 2007 (Directive 2007/2/EC) came into force on the 15th May 2007.

Furthermore, there is the Global Monitoring for Environment and Security (GMES) initiative, which aims to develop data infrastructure and services for tackling vital environmental and security issues. The services provided by GMES – mapping, support for emergency management and forecasting – will be vital for security, risk management and management of land use and other resources (cf. www.gmes.info).

Group: 2.3 RTD to empower the non-professional end-user

The recommendations in this section address a range of systems, applications and content services for non-professional access to, and interaction with, cultural heritage content. The following areas are covered:

- User-created Web-based content and metadata,
- Virtual environments,
- Mobile location-based and context-aware services,
- Ambient intelligence environments, and
- Augmented Reality systems.

The recommendations are presented in this order and proceed from short-term to longer-term research priorities.

Recommendation: 2.17 Investigate and examine appropriate approaches to user created content and metadata

Popular platforms for sharing user-created content (e.g., Flickr for image sharing) or bookmarks (e.g., del.icio.us) and widely used 'social software' tools such as Weblogs have brought about an explosion in user-generated content as well as simple medatata such as keywords and other annotations (so called 'folksonomies'). Cultural heritage institutions should be aware of people's increasing interest in expressing themselves, sharing ideas, their own material and metadata. The metadata are typically freely chosen keywords (i.e., a flat namespace) which can still be exploited through mechanisms such as 'tag clouds' to discover potentially interesting resources (though without embedded semantics).

Making use of such 'social software' or Web 2.0 applications can allow users to be involved in online exhibitions and virtual communities that may form around certain cultural heritage topics, artefacts and sites. However, such activities put the user and user-generated content, not formal institutions and their authoritatively-curated content, at the centre. The challenges implied in this are profound and will raise issues of ownership of content, liability, loss of authority, public perceptions of the institution, etc. To successfully address these issues research must be carried out on, and careful experimentation made with, appropriate approaches that work for cultural heritage institutions.

Recommendation: 2.18 Examine further the success factors for implementing 3D multi-user virtual environments

Interactive Virtual Environments (VEs) are of high interest to the CH sector as they allow for providing enhanced access to cultural assets and synergies with other domains such as education and entertainment. VEs particularly will be considered for purposes such as presenting collections that cannot be exhibited in a traditional way because of lack of space (i.e., storage of the majority of museum-held artefacts at any time), fragility of artefacts, or because the assets are virtual reconstructions of objects or places that have been partially damaged or destroyed, or entirely lost.

For end-user purposes 3D virtual environments will usually be the most adequate way of exploring and communicating with other learners. In this context, the huge success of Web-based multi-user 3D VEs should be noted. For example, in the Second Life environment in 2007 about 150 galleries, museums, sculpture parks and historic environments have already been created.

It seems timely to bring together and evaluate the lessons learned so far with multi-user 3D VEs created by cultural heritage organizations, often in the framework of European or national R&D projects or within environments such as Second Life (e.g., technical frameworks, capability to attract and retain users, effectiveness of different educational paradigms, total cost of ownership, sustainability within a commercial environment etc.). Further cultural heritage investments in 3D multi-user VEs will require a good understanding of the critical success factors for achieving sustainable results.

Recommendation: 2.19 Consider carefully the available opportunities for providing mobile, location-based and context-aware cultural heritage information services:

Mobile applications are highly relevant to the tangible cultural heritage sector for providing information services to visitors to archaeological sites, monuments, historic town centres or interesting places of a regional cultural route. In this context a service will not only deliver general purpose information, but will focus on information that is relevant to the particular place and cultural interests of the visitors. Therefore, the service must be capable of locating the user (location-based) and providing the information adjusted to the context of use (context-aware).

Mobile location-based heritage information services most often will be implemented on existing commercial networks to offer more than general purpose information. An analysis of experience that has been gained in such initiatives across Europe would be helpful to inform and guide newcomers to this field. At the same time, applied research in this field should keep an eye on advanced solutions that are already available on the market or in preparation by the major commercial players. They roll out ever more sophisticated 'added-value' location-based and navigation services, hence, R&D topics must be carefully chosen so as not to 're-invent the wheel'.

In particular, such topics will be related to the aspect of context-awareness in mobile information services (e.g., socially aware applications) which requires much more modelling of the context of use and technical capability to support novel concepts of interaction with CH information sources, including for example mobile 3D content or historic avatars.

Recommendation: 2.20 Exploit new generations of mobile devices' capability for interaction with 3D content and avatars

New generations of mobile devices with higher storage and computational power, better displays and graphics accelerators will allow for exploiting high-value CH content in location-based services. Applied research should focus on the opportunity to provide richer user experiences through 3D visual content with educational information and interaction with historic avatars.

Recommendation: 2.21 Develop self-learning systems that allow for dynamic provision of content and guidance

Capability to personalise location-based and context-aware services for cultural heritage routes or larger sites has remained rather limited. Leverage in this capability will require a dynamic adaptation of the provision of content and guidance according to the user's orientation, behaviour, and shifting interests in response to local conditions. Research on such self-learning systems that capture and analyse a multitude of different data during the interaction process could lead to a new generation of truly personal mobile guidance and storytelling, also positively challenging the visitor to explore and gain a deeper understanding of cultural heritage places.

Recommendation: 2.22 Explore further group-centric applications for shared cultural experiences

While visitors to CH sites often are families or groups of students, current location-based mobile applications are predominantly single-user based or allow for only limited interaction among the visitors. Future applied research and development should focus more on applications that support collaborative exploration of and learning about a site. Results from prototypic games-based, collaborative e-learning experiments and other group-centric approaches should be examined to identify perceived shortcomings in the support of group communication and collaborative access to, and manipulation of, content. Furthermore, capability of systems to capture and analyse group behaviours in specific environments and with different kinds of content will be of particular interest.

Recommendation: 2.23 Develop ambient intelligence environments in order to help standardize applications for visitor experiences and site management

So called 'ambient intelligence' applications for CH sites are still in the research prototype phase. Such applications use mobile and distributed technologies and numerous sensing and computing devices distributed throughout the environment. These are small, wirelessly networked devices that can share data among each other and communicate with the visitor. While some devices are visitor-centred, others, such as embedded sensors, may form a monitoring system that collects, analyses and informs the site management about environmental conditions – temperature, humidity, vibration – around the exhibits. Thus, damage through environmental or visitor impact may be minimized or prevented, for example, by routing visitors away from areas that are overcrowded.

Among the main challenges of such environments are continuous tracking and servicing of visitors where a number of technologies are competing, context awareness, including the understanding and exploitation of individual and group behaviour (e.g., for personalization of content and shared experiences), and physical constraints of the user devices (e.g., battery power, screens in outdoor environments). Indeed, difficulties have been found in further developing prototypic installations developed within research projects into solutions that work in practice, and useful developments such as specialized sensors for orientation have remained within the research environment or shown limited exploitation in sites and museums.

Ambient intelligence environments can allow the enhancing of visitor experiences as well as novel ways of managing CH sites; however, there are still a number of technical obstacles that impede the realization of more complex environments that could deliver the envisaged benefits. While these obstacles may be overcome within a few years, a wider deployment in the CH sector will require standardized applications to be developed, based on software architectures and sensing and computing units that are easy to implement and manage. Of particular interest will be applications that allow both visitor support as well as new ways of site monitoring and other CH management tasks.

Recommendation: 2.24 Further develop Augmented Reality systems for use outdoors at cultural heritage sites

Augmented Reality (AR) applications combine real and virtual scenes (2D or 3D visuals) and other information in the user's perception of the environment. This distinguishes AR from virtual simulations that deliver an entirely computer-generated interactive environment. AR applications are of high relevance to tangible cultural heritage because they allow for augmenting the perception of artefacts that are presented in a museum exhibition or outdoor place such as an archaeological site or monument, including story-telling by, and interaction with, virtual historic characters.

The technical problems of indoor, highly controllable applications are already well understood, so that a stronger focus on R&D for outdoor applications is to be expected. Indeed, such applications pose particularly difficult problems with respect to user position and orientation tracking, display technology, content rendering and

alignment, changes of lighting conditions, and a number of other issues (e.g., cumbersome current equipment in need of miniaturization).

There are also limits still in current AR technology for simulating scenes of detailed virtual environments and humans within real places (e.g., with respect to consistent lighting). These are expected to be overcome through fine-tuning of rendering, registration, and animation solutions.

Recommendation: 2.25 Explore 'socially aware' and 'open world' interaction frameworks for Augmented Reality applications

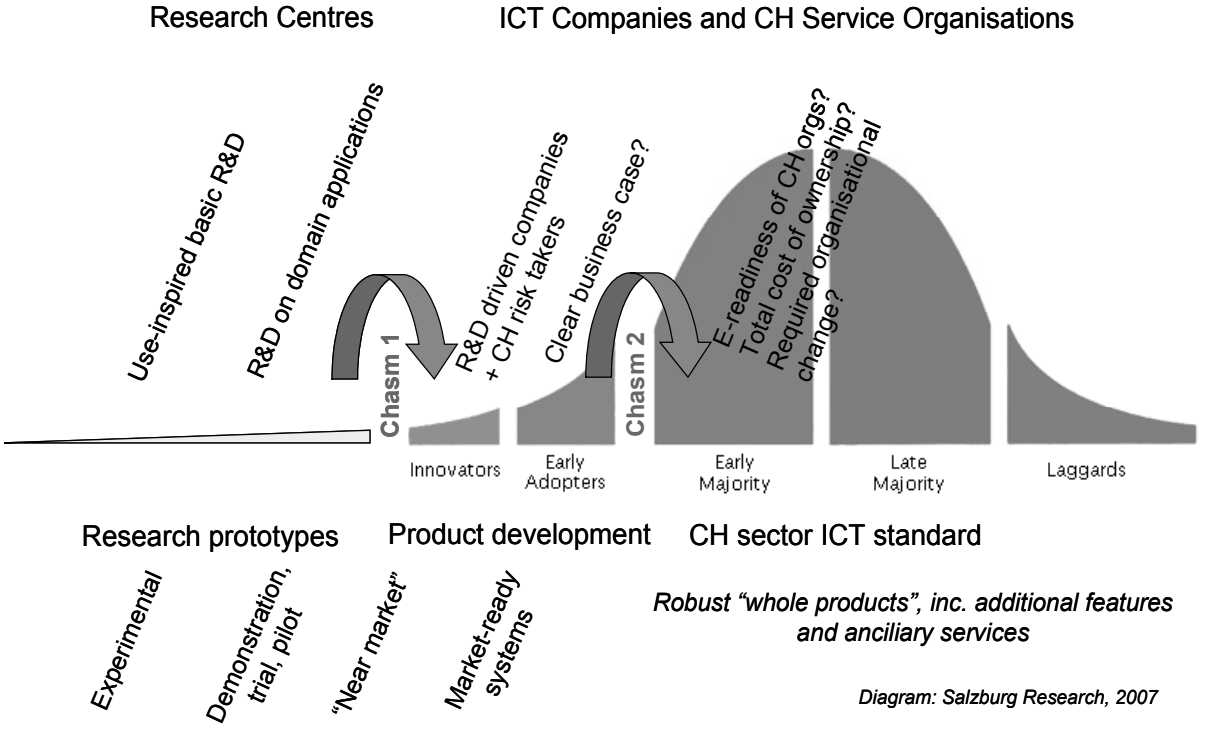
The most long-term research challenges in AR applications for cultural heritage experiences are considered to be applications that allow for 'social awareness' of, and interaction with, virtual historic characters. In this field, major advances should be sought regarding the conceptual and technical frameworks for interactive storytelling. This would require user-awareness of the virtual humans, i.e., capability to identify and respond to statements, gestures and mimic expression.

While it may be relatively easy to realize simple interactive sequences with virtual characters, a more difficult R&D challenge is open, not predefined, interaction. This would require some 'open world' artificial intelligence on the side of the virtual characters, or, rather, the system that controls their interaction in response to identified input from the user.

Group: 3 Knowledge transfer, market development, and uptake

Valorisation of the investment made in technological research and development for innovative ICT applications for specific sectors like cultural heritage is an important point on the agenda of policy-makers and funding bodies. The question is how prototypes and other research results, most of which originate from publicly funded projects, could be better exploited through the development of market-ready solutions. Furthermore, public agencies and business associations often will ask what they could do to help make cultural heritage organizations more 'e-ready' and create business opportunities in this sector.

The Figure below depicts why an effective transfer of research results and wider adoption of innovative ICT solutions is difficult to achieve in the cultural heritage sector:



The Figure shows two 'chasms' in the diffusion of research results:

Chasm 1: This chasm concerns the transfer of 'near market' ICT prototypes to innovators and other early adopters in the CH sector. This transfer is hampered by the following situation: 1) There are only few research-driven companies that develop results of applied research into robust working solutions for the target market CH, and 2) this market is not characterized by strong incentives for seeking a competitive advantage as well as capability for the risk-taking that is required when adopting novel applications that have not so far proven their benefits. 3) For academic computer scientists the research issue is typically regarded as solved once the near market prototype has been produced and results published. Little career advantage is perceived in further investment of time.

Chasm 2: This chasm concerns the adoption at a late stage by many institutions in the CH sector of a more mature application, a whole product with additional features and ancillary services. The main problem here is that most CH sector institutions are small organizations that lack technical staff and support and are not able to cover the total cost of ownership for ICT applications from their operational budget. Many of them would be happy enough if they could afford a state-of-the-art Web site, have in place a better collection management system or could enhance exhibitions with.

In order to overcome these chasms, novel business models for knowledge and technology transfer, market development, and support of cultural heritage institutions in the use of ICT applications are required. The following measures are suggested.

Recommendation: 3.1 Leverage the knowledge base in progress, inhibitors and drivers in the digitization of tangible CH in 3D format

Although there is a rapidly growing number of limited experiments in 3D asset acquisition across Europe the initiatives tend to be localised (partly since the digitization is normally in situ) and to include very limited metadata and digital provenance. There is therefore a lack of ongoing, systematic data acquisition on the current level of digitization and use of 3D content by cultural heritage institutions across Europe. To provide decision makers in the sector with a solid knowledge base, systematic mechanisms for collecting data through national and regional bodies on planned, ongoing and completed digitization projects should be established, covering both initiatives in museums and the many 3D digitization projects related to built heritage, archaeological sites and cultural landscapes. This should also attempt to capture the lessons learned to gain a better understanding of potential inhibitors, drivers, and barriers to digitizing 3D CH assets, as well as providing intelligence to identify contributions to a critical mass of 3D content through the European Digital Library initiative.

Recommendation: 3.2 Consolidate and disseminate knowledge in different approaches to 3D data capture

The field of 3D capture in tangible cultural heritage is currently supported by a wide range of technologies, applicable in different circumstances and requiring different operations (e.g., data-handling and post-processing). As new technologies are produced and individual technologies are combined or further developed to improve applicability more choice becomes available in individual circumstances. Some recent research has been devoted to comparing the results from different approaches, but this is a moving target requiring on-going maintenance. To encourage the growth of a critical mass of 3D content an ongoing process to garner the available knowledge on the best approaches in each situation, and on the cost/quality trade-offs, should be implemented to make information readily available.

Recommendation: 3.3 Improve dissemination of critical knowledge about procedures to reduce digitization costs

Perceived cost is a major inhibitor of the wider participation of museums and sites in digitization of artefacts and sites. Hence, it is still very worthwhile to pursue the objective of reducing by 50% the costs in 3D digitization. Besides technical improvements this is to a high degree also a matter of procedural methods, control of cost drivers, etc. The critical lack in procedural knowledge should be addressed immediately through gathering and consolidating available expertise and disseminating it widely in the relevant digitization communities. This could be an important function of a European or leading national service centre in 3D digitization.

Recommendation: 3.4 Tackle roadblocks in the exploitation of R&D results

The mechanisms required for ensuring an effective exploitation of R&D results need to be considered more thoroughly. In recent years a lot of progress has been made – for example, by projects funded under the Fifth and Sixth Framework Programmes – but much of this has yet to achieve its market penetration potential.

In fact, the roadblocks on the journey from research prototypes to widely adopted applications that work in CH practice are huge. In most technology areas these are overcome by companies that form an interface between R&D and innovation-orientated organizations. They develop prototypic applications into market-ready solutions. However, such an interface has not evolved to a sufficient degree in the field of cultural heritage ICT.

A large number of spin-off companies based on prototypic applications specifically developed for CH purposes is rather unlikely, because the CH sector is known to be a difficult market and can rarely be considered as a company's core field of business. It is clear that the CH sector is not very attractive to academic entrepreneurs. This also may have added to a tendency to believe that research projects in CH ICT are finished off by simply making results available through a Web site as Open Source software, with no related effort made to nourish a committed developer and user community.

There needs to be a committed developer community, including the original creators of the software, who take care of maintaining, further developing, and servicing the software. Another solution is encourage transfer of research results – software, prototypic devices, etc. – to companies who might develop new or enhanced products or services based on them.

Recommendation: 3.5 Investigate a wider range of potentially more effective models for the transfer of new knowledge and technologies from applied research and development

Results from applied research and development such as ICT prototypes usually cannot be directly taken up by CH institutions. Rather, a transfer to organizations that develop market-ready solutions and offer services (implementation, maintenance, upgrades, etc.) is required. Models for this transfer include, but are not limited to, Web-based services and accompanied training and other services, co-development partnerships, and public–private expertise centres.

Although knowledge and technology transfer is crucial for reaping the benefits of dedicated, use-inspired research on ICT applications for the CH sector, little is known today about the current use and effectiveness of these different deployment models. Therefore an effort should be made to identify, gather, summarize and disseminate existing experience in the application of these models.

Recommendation: 3.6 Gain better knowledge of the CH ICT market and companies that operate successfully in this market

The CH sector is understood to be a difficult market due to a number of reasons, e.g., small IT budgets, lack of technical expertise, 'different business culture'. In practice, this can mean that CH customers sometimes use the companies for free consultancy, tenders may be ill defined, projects have long lead times, etc. Consequently, most technology companies do not consider the CH domain as their core business. The degree of specialization is rather low, which leads to the criticism that specific needs of the domain are often not met.

However, as can be seen from trade fairs or exhibitor spaces at relevant conferences, there are quite a few companies who have developed expertise, products and services for this market. Some companies also participate in European and national research programmes. For example, in the Fifth and Sixth Framework Programmes 184 companies, most of them SMEs, participated in the field of Cultural Heritage Applications. In order to establish effective ways of moving research prototypes closer to the CH ICT market, a better knowledge of this market should be acquired and relationships established with companies that already operate successfully.

Recommendation: 3.7 Establish cultural heritage ICT expertise and service centres

EPOCH has identified the need to establish CH ICT expertise and service centres, particularly for applications whose implementation requires expertise that cannot easily be found in the market (e.g., 3D virtual environments). In addition, smaller CH organizations would need much support in order to benefit from new technological opportunities.

The establishment of CH ICT expertise and service centres could lay the groundwork for the much stronger linkage required between applied R&D and CH experts and practitioners, which should be based on true interdisciplinary efforts. Particularly if such centres are established in conjunction with research centres that specialize in CH ICT, this may facilitate a steady stream of knowledge exchange between researchers, technologists and experts and practitioners from – and clients of – cultural and scientific heritage organizations.

In a much more effective way, curators, arts and humanities scholars, educational programme managers and experts from cultural hotspots, such as historic city centres or larger heritage sites, could be involved in the

development of prototypes of new applications, and feedback could be collected from professional users of and visitors to sites, monuments and museums.

Recommendation: 3.8 Promote sharing of lessons learned in business support models for SMEs and social enterprises in the CH sector

On the regional level a strategy is recommended of combining the promotion of cultural and creative SMEs with the aim of serving ICT needs of museums and sites. Such needs range from state-of-the-art interactive Web sites, including virtual presentation of sites, exhibitions, etc., to more CH-specific applications and services.

Public administrations and agencies who want to leverage the 'e-readiness' of the region will support business incubator projects that focus on CH digital resources and innovative Web and other solutions, promote a closer collaboration of SMEs and museums within creative clusters, and support social enterprises that specialize in CH specific applications and services. Lessons learned from making use of such models should be collected and shared among regions throughout Europe.

Group: 4 Understanding socio-economic impact of tangible cultural heritage and ICTs

Europe has a rich and diverse physical cultural heritage. Preserving and making use of this heritage for purposes such as cultural participation and learning, cultural tourism, regional development and cultural creative industries are of vital interest for Europe's economic competitiveness, job generation, urban and regional regeneration and citizens' quality of life (Lisbon Agenda).

The most obvious example is the tourism sector, which is worth hundreds of billions of euros in annual turnover in Europe and is one of the most important sectors of the European economy. Depending on the definition of the tourism sector, its contribution to the EU's GDP varies from 4% to ~11% and the number of people employed ranges from 7.3 million to 20.6 million, respectively. Estimates are that there are 1.171 million jobs in 'cultural tourism employment' in Europe (EU25), which is 15% of their figure for total employment in the tourism industry and 0.6% of the total employment.

The wider employment effect of cultural heritage museums and sites is thought to be considerable. For example, in France direct employment in 2002 of the cultural heritage sector of 44,880 produced related employment in the tourism sector of 176,800 (a ratio of 1:4) and further induced employment in other sectors of 260,830 (a ratio of 1:6). In addition, 41,700 people were employed in the conservation and maintenance of physical cultural heritage. Similar ratios (or 'multiplier effects') are given in a number of other studies. For example, in the UK the National Trust reports that it generates between five and nine additional full-time equivalent posts for every job for which it is responsible.

The Lisbon Agenda includes the goal to make the regions and cities of Europe more attractive places to work, live and invest and culture and cultural heritage are understood to be crucial for the specific character, identity and image of regions and towns and an important element of the quality of life of the residents. Consequently regions and towns not only invest in the infrastructure for cultural life (e.g., museums, places for performing arts, etc.), but tend to support cultural projects more actively.

What is hard to quantify, though, is the impact that individual investment choices have on the 'value added' by culture and cultural heritage. In part this is because the incremental effect on value in a country, region or town may be difficult to isolate and in part it is because the macro-level economic advantage may not be directly realized by those organizations which make the investment.

However, Europe spends many billions annually on the education of its citizens, a component of which is in their education as citizens engaged in their history and heritage. The interest and participation of citizens in culture and cultural heritage is considerable, as shown by the important role of volunteers in the sector as well as straightforward on-site and online visitor numbers.

There is a promise that advanced ICT applications and digital content can further leverage the societal benefits of cultural heritage, but the question is how significant these benefits are. This means that wider strategic frameworks such as regional development and competitiveness must be considered, within which cultural heritage and ICTs can make a particular contribution.

Group: 4.1 Basic issues in a socio-economic research agenda for cultural heritage and ICTs

The following recommendations address some basic issues in a socio-economic research agenda for cultural heritage and ICT. These concern appropriate models and empirical data for policy making and decisions on

investment in the preservation and promotion of cultural heritage, adoption of ICT applications in the heritage sector, and institutional capacity building.

Recommendation: 4.1 Fill the need for empirical models and data for policy- and decision- making on investments in cultural heritage

There is a great need of empirical models and data that allow for a systematic valuation of economic, social and other impacts of cultural heritage and, thereby, allow for well-informed decision-making on cultural heritage policies and investment. This also concerns the investment in the digitization of cultural heritage (e.g., tangible cultural heritage in 3D format).

In recent years, there has been some progress in cultural statistics based on harmonised data available in Eurostat, UNESCO, Eurobarometer and other sources (for example, see the Eurostat Pocket Book on Cultural Statistics issued in October 2007 (Eurostat 2007b). However, these statistics do not cover the heritage sector particularly well. Efforts in this field typically use the approach of creating country reports or 'national profiles' covering a number of agreed themes, e.g., the COMPENDIUM of the Council of Europe and ERICarts; the HEREIN database on national heritage policies; EPOCH's 'State of the Union' survey 2004/2005 on policies, practices and developments in cultural heritage ICT projects. The intention often is to amend such country profiles with statistical data and to achieve some comparability, though little has been achieved so far in this field.

In particular, data must be collected, analysed and presented in a way that allows decision-making and controlling the outcome of decisions. One example of good practice is the UK Government's Department for Culture, Media and Sport (DCMS), which for about the last 10 years has asked cultural institutions to increase and broaden the social impact of their activities. Consequently, today the performance indicators, statistical data and reporting available on the sector in the UK represent best practice that is seldom met by other countries (cf. the DCMS annual reports and the many other reports prepared by leading organizations such as English Heritage, Museums, Libraries & Archives, and others).

Recommendation: 4.2 Establish evidence of 'good value for money' of investments in tangible cultural heritage and ICTs

While the socio-economic relevance of cultural heritage sites for regions and towns is often emphasised, there seems to be a lack of convincing, empirically-based arguments for investing in the preservation, promotion and valorisation of such sites. In addition, the business case for investment in cultural heritage ICTs is often not easy to establish. For example, what is the added value of a museum Web site or of digital presentation displays in the visitor centre of an archaeological site?

It would be much easier to compete for scarce funding resources if cultural heritage managers could point out expected enhanced socio-economic relevance by an intended project, e.g., based on evidence from similar investments elsewhere. Demonstrating 'good value for money' could have a considerable impact on heritage policies, public funding, private investment and public–private partnerships in cultural heritage and ICTs.

Recommendation: 4.3 Promote more studies that demonstrate benefits of implementing particular cultural heritage ICT applications

Of particular importance for a wider adoption and greater impact of ICT in the cultural heritage sector are studies that assess and demonstrate to individual sites the benefits of implementing individual ICT applications. In fact, the business case for many applications may not be as clear as is claimed by the technology providers. Unfortunately, there are but few studies available that confirm that visitors are willing to pay for using such applications, or even use them to a considerable degree if they do not have to pay an extra fee. These studies suggest that there is too little knowledge available for decision-making on investments in cultural heritage ICT applications, and that current approaches of implementing such applications at CH sites may not bring about the expected benefits.

Recommendation: 4.4 Develop indicator-based models for regional and urban development strategies concerning cultural heritage

It would be helpful to have solid input–output models, indicators and tools available for identifying more clearly the socio-economic benefits of cultural heritage at the level of a region or a town. Such models also should support in drawing out and evaluating alternative regional and urban development strategies, for example, with respect to the tourist-carrying capacity of heritage places. Particularly in the case of places that already attract or want to attract tourists mainly based on their cultural heritage, asset models and indicators are needed for assessing their

tourist carrying capacity, i.e., their ability to absorb certain levels of visitors and related infrastructure before the CH values of the place are diminished to an unacceptable degree.

The commercial use of heritage places may generate increased income and employment, but at the cost of some degree of physical degradation as well as impacts on the social carrying capacity of the area, i.e., there may be some stress on the side of the host population due to the presence and behaviour of tourists in the area. Therefore it is important to not only evaluate the economic benefits of a heritage site, but also identify and counteract potential negative social and environmental impacts. Indicator-based models, backed up with regular surveys, could provide an early warning system and inform the implementation of measures for establishing limits of use and development that are permitted within controlled heritage areas. This would also allow assessment of the achievable balance between volume tourism and tourist trade with high value but lower volume.

Recommendation: 4.5 Identify and address the need of education, training and continuing professional development in cultural heritage ICTs

Because of the re-examination of the societal roles and relevance of cultural heritage institutions in today's society, rapid innovations in ICT, and changes in user demands there is a considerable demand for upgraded and new qualifications in the sector. Indeed, education, training and continuing professional development is a key element for achieving the potential socio-economic impact of cultural heritage.

The required update in competence profiles, for example, comprises knowledge and skills in site management, user demands in services, partnerships with other sector organizations and businesses (e.g., tourism providers, creative businesses), effective deployment of new ICT (e.g., digitization, enhanced online access, on-site interactive installations), and evaluation of social and other impacts. As in other sectors, there is a need for re-training people who already work in cultural heritage institutions, though the challenge in this sector can be expected to be considerable. In particular, it is felt that there is a critical lack of required ICT skills, and the sector simply cannot wait for new generations of computer- and IT-literate heritage professionals. Which particular knowledge and skills are needed for which positions and tasks, and how they could be best provided for, may well be one of the most important research questions in the valorization of cultural heritage.

Group: 4.2 Methods and tools for capturing and analysing the socio-economic impact of cultural heritage

The heritage value of a place or object, i.e., its specific historical, symbolic, spiritual, aesthetic and other aspects, is the major reason underlying its conservation as well as the basis for its economic and social benefits and impacts. From the economic point of view, the value of a cultural heritage asset lies in the benefits that can be derived from its direct and indirect use and, even, non-use values.

Direct use value of a heritage site or historic building can be captured comparatively easily, but indirect use values are difficult to evaluate. Furthermore, people derive value from having the option to visit a heritage place even if they never do ('non-use value'). Methodologies and instruments for capturing different benefits and impacts of tangible cultural heritage are therefore a particularly important field of research and development. Furthermore, standardization, identification of best practices and lessons learned, and guidance material are of high importance.

Research and training in this sphere should enhance the understanding of the heritage system and give heritage site managers a much clearer comprehension of how alternative choices of activity and investment can influence impact in economic, social and environmental terms. There also is a need for linking plans and activities for leveraging the impact of sites more fully into medium to longer-term development strategies of regions and cities, e.g., sustainable development and quality of life or cultural cluster or/and cultural tourism strategies.

There are different methods for capturing the value people attach to cultural heritage places and features, which can be subdivided into market and non-market analyses.

Recommendation: 4.6 Develop standardized and easy to use tools for market analysis of the economic impact of heritage sites

Market analyses are the traditional analyses carried out by economists which identify direct and indirect expenditure effects. While these techniques can determine the more easily measurable economic impacts of a cultural heritage site, they do not reveal the full range of values produced by a site.

But analysis of the economic impact of course is an important component in the overall valuation of a heritage sites. However, there is a lack in standardized and easy-to-use tools for capturing and analysing this impact of

heritage sites (one rare example is the 'Money Generation Model' for national parks in the USA). The development of such tools for heritage site managers should be a matter of priority. Standardized IT-based tools will not only allow for automating certain tasks, but may also provide the basis for aggregating, analysing and comparing impact figures on the regional and national level.

There also is scope for greater research devoted to deepening the understanding of heritage impact drivers through acquiring data at similar sites across Europe. There appear to be considerable differences between the data available from various European countries. There is currently a clear north–south divide regarding such data availability, with more data being available from northern Europe and other 'old' EU member states.

Recommendation: 4.7 Promote a wider usage of non-market valuation methods in the cultural heritage sector

Non-market analyses try to capture values and benefits of heritage sites that are not picked up by market-based valuations. The most widely used non-market valuation methods use stated preferences for estimating respondents' 'willingness to pay' for benefits of heritage sites or services (Contingent Valuation Method) or identifying how people would choose between, rank, or rate alternatives, e.g., in the context of a planned investment in a heritage site (Contingent Choice Method).

While in the field of environmental economics more than 2000 contingent valuation studies had been conducted by the end of the 1990s, the cultural heritage sector is lagging far behind in making good use of such methods for determining economic and other values of different sites. In 2007, some 60 relevant studies could be identified, of which only one included the valuation of a planned multimedia service. Consequently, at present the opportunity for using benefit estimates from similar sites is also very low.

There is a pressing need of more valuation studies on the diverse array of heritage sites. Such studies should be designed to address specific questions of heritage policy and investment, including issues of tradeoffs among competing objectives, for example, between site preservation and access.

Recommendation: 4.8 Develop tools for non-market valuation of cultural heritage ICT applications

The application of contingent valuation methods to cultural heritage ICT applications so far has been very low. As with the valuation of heritage sites the main reason is cost as such studies are resource intensive. Typically, public institutions do not charge money for on-site ICT-based installations, online services or virtual exhibitions, and visitors appreciate using them for free. However, research needs to be directed towards determining the cost/benefit ratio for the institution and community for the investment. For example, measuring the effect of an online exhibition of a heritage site on the local economy is possible if it can be established how many visitors were motivated by the exhibition to visit the physical site and spend money in the area. In view of the resource limitations of the heritage sector, the development of valuation methods and tools that are easy to deploy and deliver solid results should be seen as an important area for future research.

Recommendation: 4.9 Provide systems and tools for cost-effective ICT-based data capture for valuation studies

ICTs provide an opportunity to reduce data acquisition costs for valuation studies, but much further research is needed for developing simple, robust and user-friendly tools that may be employed by heritage sites. For example, the ability of different devices to capture user or environmental data will vary considerably. There may be areas where fixed or portable technologies are more practical to employ and may be more or less cost-effective. Furthermore, in the evaluation of the cost-effectiveness of the applications their total cost of ownership must be considered. Moreover, in on-site and online visitor studies there is the question of which approaches are likely to find a sufficient rate and quality of response. Visitors are increasingly reticent about using Web-based surveys, but they have been shown to be more likely to provide responses to questionnaires provided on portable devices.

Recommendation: 4.10 Aim at advances in techniques that allow for reducing the complexity and cost of heritage valuation studies

Most impact studies undertaken in the heritage sector to date have usually focused on a single impact dimension at one moment in time. There is scope for greater research devoted to the broader study of the heritage system. Particularly the social and environmental benefits and impacts of heritage sites will need much more attention. As in the case of economic impacts, in these fields there are levels of study that increase in cost and complexity. For example, an assessment of the social impacts of a heritage site increases in complexity and cost from simply

counting the numbers of visitors, to determining the socio-economic group of those visitors, on to conducting studies of community benefits or the site's role in the cultural identity of a region. Similarly, with an assessment of the environmental impact of a heritage site, simple calculations of energy use are relatively easy to obtain, but quantifying the percentage of recycled waste and carbon emissions or assessing the contribution of a site to environmental sustainability requires more resources to acquire the information.

If heritage sites wish to conduct more complex analysis, today the time and resources required to do so may be prohibitive. Hence, research should focus on advances in techniques that allow for reducing the complexity and cost of more sophisticated impact studies that could be conducted by heritage site managers or regional agencies. Without such techniques the burden of impact studies will divert critical resources away from core business processes at heritage sites, or impact will simply be ignored, unless impact valuation is imposed from above.

Recommendation: 4.11 Provide heritage impact analysis in support of policies that ensure a fair sharing of economic benefits from well-preserved and managed heritage sites

Input–output analyses have shown that heritage sites can have a high economic impact on the regional economy if direct, indirect and induced effects of expenditure that can be related to the site are calculated. Yet while the 'capture rate', i.e., all expenditure retained in the regional economy, may be high, a heritage site usually receives only 6 to 10% of the total spending. Most cultural heritage sites will not be economically sustainable by this income alone.

Hence, there will often be a need to leverage the financial return to the site to ensure its long-term sustainability, e.g., an appropriate flow-back from taxes as public subsidies or financial support by the main beneficiaries. For example, operators in the tourism sector often see heritage resources as available 'for free', i.e., expect the host community to bear the costs of developing and maintaining a site and related infrastructure and services (including roads, water supply, electricity, sanitation, waste collection and disposal, security, etc.).

Particularly in cases where there is a high leakage of revenues that are not reinvested in the local/regional economy, policies will need to be put in place that providers of goods and services from the host community benefit from the public investment in heritage sites and that the public authorities and local businesses have negotiation power vis-à-vis tour operators.

Group: 4.2 Research challenges in the development of sustainable cultural tourism

Cultural tourism is seen as a particularly interesting segment of the tourism industry and a key factor for the economic development of many European cities and regions. It is expected that in the next few years the competition for visitors between cultural tourism destinations will become fierce. Newcomers and established destinations will need to be very inventive to stand out among the many competitors. The required innovation not only includes measures that allow for exploiting positive aspects of cultural tourism but also considers the possible negative impacts of tourism development, particularly at heritage places with limited tourist-carrying capacity.

Among the potentially positive aspects of cultural tourism development are the following: People increasingly look for authenticity and meaningful experiences, opportunities for self-development and personal fulfilment, and quality in tourism environments and offerings. Cultural heritage tourists tend to spend more money while on vacation and are more likely to be from an older age group, hence, the trend towards the 'aging society' works in favour of heritage destinations.

However, there also are many critical aspects of cultural tourism which regions and towns should consider when investing in the development of heritage sites: There is a rapid consumption of heritage places (e.g., by day-trip visitors) and return visits are unlikely. At the same time, heritage places may be 'mummified', i.e., imprisoned in their immutable uniqueness and stringent expectations of visitors that leave little room for renewal. Also, the displacement of traditional economic and social functions through tourism infrastructure and the degradation of public spaces by crowds of visitors, increased levels of traffic and parking, thoughtless behaviour by visitors, etc. can be considerable. Indeed, local people will often face a situation where they must compete with tourists for space, local services and opportunities to enjoy their life.

The typical consumption patterns and potential negative impacts of heritage tourism make a proactive tourism management by regional and local authorities and site managers a necessity. The heritage site and the host community should be the most important stakeholders in cultural tourism development, and local authorities must understand that protecting the site and the quality of life of the local people is essential for sustaining tourism in the longer term.

A large part of tourism in Europe is motivated by having the opportunity to experience and enjoy cultural and natural heritage sites. Therefore, the sustainability of heritage sites in environmental, social and economic terms should be high on the agenda of policy-makers at all levels. While tourism is often seen to threaten heritage sites by unsustainable use levels it also is important for their long-term viability. As the different purposes of heritage sites (preserve) and tourism organizations (exploit) will often be in conflict, mutual understanding, partnerships and cooperation for sustainability probably will be the best way to prepare the ground for acceptable tradeoffs and sustainable solutions.

Recommendation: 4.12 Address the need for targeted research, guidelines and advice on sustainable tourism development

There is a clear demand for targeted research, guidelines and advice for sustainable cultural tourism strategies that take advantage of potentially positive societal trends and, at the same time, prevent potential negative impacts on heritage sites and the host community as far as possible. This is emphasized in charters and declarations such as the 'Global Code of Ethics for Tourism' of the United Nations' World Tourism Organization (1999), the ICOMOS 'International Cultural Tourism Charter' (1999), and a number of recent declarations, for example, the 'Malta Declaration' (May 2006) of the pan-European federation for cultural heritage Europa Nostra, and the 'Dubrovnik Declaration' (September 2006) of the Council of Europe's Congress of Local and Regional Authorities (Culture and Education Committee) together with the European Association of Historic Towns and Regions. These declarations indicate an increasing unease regarding the commercialization and loss of local cultural heritage through tourism activities.

Recommendation: 4.13 Assess and consolidate the knowledge in models and indicators of sustainable tourism

Sustainable tourism is a complex field of research which spans economic, socio-cultural and environmental aspects of a tourism destination that are closely interlinked. Moreover, while sustainable tourism is envisaged as a well-balanced situation, it is a moving target that must be aimed at amidst dynamic change, conflicts, complex interdependencies, uncertainty, and impacts of factors that are not all controllable at the level of the destination. There is a growing volume of research on models and indicators of sustainable tourism in need of assessment and consolidation for further progress in particularly critical areas of cultural heritage tourism development and management (some of which are addressed in the recommendations below).

A review of the state-of-the art in 'sustainable heritage tourism' is missing and would, indeed, be very beneficial to have, particularly if conducted on a regular basis. What is evident, though, is that at present there is a lack in comprehensive analysis based on a systemic and interdisciplinary perspective, which may be overcome only in the longer term.

Recommendation: 4.14 Assess and leverage the usefulness of the Tourist Area Life-Cycle Model and the concept of carrying capacity in the area of heritage tourism

Since its introduction in 1980, the Tourist Area Life-Cycle (TALC) model proved to be a useful reference point for describing and discussing stages of tourism development at different types of destination, in particular, islands and coastal resorts. Applications of the model to heritage areas are rare, although it has been observed that such areas may experience particularly negative effects in the later stages of the life-cycle.

The concept of carrying capacity in the context of tourism refers to the ability of a destination to absorb certain levels of tourism infrastructure and visitors before the values of the place are diminished to an unacceptable degree. A certain level of standardization in the application of the concept has been achieved and the research has also informed various visitor management and impact assessment approaches. It would be beneficial to have an assessment of the practical impact of the concept, in particular with respect to efforts of defining limits of use and development that are permitted within controlled heritage areas.

Recommendation: 4.15 Expand the knowledge in, and applicability of, indicators of sustainable heritage tourism

Indicators play a key role in monitoring tourism destinations and adjusting policies and measures if sustainability targets are not met. But the indicators used must be based on a coherent conceptual framework that allows for a systemic sustainability assessment and well-informed decision making and management. This requires having an

integrated, multidimensional understanding of the system to be managed and sets of indicators that reliably reflect the interdependence of economic, social and environmental processes at the destination.

There has been considerable progress in the definition of indicators and guidance on how to apply them (e.g., the guidebook *Indicators of Sustainable Development for Tourism Destinations* of the United Nations' World Tourism Organization issued in 2004 (WTO 2004b)). However, there is still much scope for targeted research on indicators of sustainable heritage tourism and advice on their use taking into account the specific circumstances of different sites.

Recommendation: 4.16 Support bottom-up approaches in documenting the impact of heritage tourism

Observers of the more recent proliferation of indicators for sustainable tourism have noted that the impact of this work on policy change so far has been limited. This is understood to be due to lack of awareness of sustainability issues, political unacceptability of many required actions, inadequate institutional responses and, of course, opposition from entrenched interests.

Therefore, hard-pressed heritage sites and communities will often need to argue their case by documenting negative impacts, carrying out questionnaire surveys, etc., and presenting suggestions on how to get a handle on negative local situations. In such situations, support from professionals in participatory research and collaborative policy-making on local sustainability issues may beneficial.

Group: 5 Integrated approaches for heritage sites and ICTs in the experience economy

There is a need to develop integrated approaches for heritage sites and ICTs that may allow for leveraging the socio-economic benefits of cultural heritage for regions and towns. One important framework for such approaches is the so called 'experience economy'. Historic towns and cultural heritage sites should be aware of the competition and develop an experiential positioning, i.e., define and create distinct experiential values for cultural tourists.

Because of the widespread borrowing of concepts that seem to be successful elsewhere, there is a considerable convergence in the strategies that regions and towns use in the development of their cultural assets. Instead of an innovative 'placemaking' that stimulates cultural creatives and attracts purposeful cultural tourists, the result is a growing number of rather sterile and inflexible cultural spaces. Typically these spaces reproduce stereotypic notions of culture and heritage and reinforce passive cultural consumption patterns. In order to stand out, regions and towns should use a distinctiveness strategy to create a unique position and brand on the cultural tourism market.

In developing a distinct, high-quality cultural tourism environment, regions and towns should combine in an integrated way several strategies. Section 11.7 illustrates the way in which historic towns must combine several development strategies in an integrated way. In the experience economy, regions and towns cannot count solely on the attraction value of built cultural heritage. Rather, an experiential positioning should be developed that also builds on other unique features and existing regional strengths. This is also important for fostering creativity and cooperation among regional stakeholders, retaining talented people, and attracting inward investment of new businesses.

ICTs and online media only are one component of strategic development among many, though, it is clear that they can help regions and towns to gain competitive advantage in several ways. These are summarized in the following recommendations with a focus on the particular challenges of communicating the experiential benefits of historic towns and sites. A number of ICT applications and online media are addressed that provide particular opportunities in the context of cultural tourism. As the Research Agenda concentrates on research needed to realize the potential of ICT support to the tasks and content of cultural heritage organizations and related stakeholders, applications such as general purpose marketing platforms, online booking, ticketing and purchasing are not addressed.

Recommendation: 5.1 Consider the high challenge of communicating experiential benefits

ICT-based communication for promoting cultural tourism should concentrate on the experiential benefits of a historic town or site, because these benefits are what will make people want to actually visit the town or site. However, communicating the experiential benefits is not easy, because the potential visitors will gain them only when actually visiting the town or site. This requires communicating the unique experiences in ways that allow the potential visitor to recognize beforehand and anticipate these experiences. Customers today want to have 'success guaranteed' before they actually buy a product or service. This is relatively easy with standardized and primarily functional products or services, but not with products and services that are marketed based on their experiential value.

Recommendation: 5.2 Make use of a new generation of dynamic Web sites and Web portal technology

It is clear that state-of-the-art Web sites will be used to present and promote features and offerings such as historic buildings and public spaces, cultural events, quality retail including labelled regional products, and quality accommodation and gastronomy. Presented with carefully chosen visuals and messages and integrated in a Web portal they will play an important role in mediating the many experiential values of the town.

Web sites that allow visitors to find and explore convincing experiential value propositions should be used, rather than a product-driven approach focused on the typical travel package. Multi-lingual content will be required, at least for the main visitor segments. While a rich Web portal can be a gateway to a virtual visit of the historic town, care must be taken that people do not get lost in a multitude of sub-pages; logging data can provide information on what works as well as points where visitors get lost.

More advanced Web solutions could provide a true 'online stage' for pre-visit interactive communication of experiential benefits. This may be realized through a dynamic creation of experience profiles/segments of the town (e.g., cultural places) according to the specific interest of online visitors. Also, a 3D virtual environment with different 'rooms' could be used.

Recommendation: 5.3 Involve local people and institutions in the communication of place-specific cultural contexts and experiences

Historic towns and sites may find it difficult to communicate their cultural richness and regional importance beyond their function as an 'attraction value' or 'brand asset'. Rather than a typical marketing strategy, a distinct approach is to involve local people in the communication of cultural experiences and place-specific cultural contexts. Besides the expertise of archivists, curators and site managers, also personal voices of people who live and work in the town can communicate to potential visitors the specificity of a historic town or site.

Recommendation: 5.4 Seek to benefit from visitors' own images and stories and communities of interest

Strongly related to people's quest for experiences and self-fulfilment is the increasing use of digital tools for documenting one's own way of life. Ever more people capture images (photographs and videos) of leisure and travel activities using digital cameras. Many place them on online content Web sites and sharing services such as Flickr or YouTube, which have seen tremendous growth in user-created content. More and more people also express own ideas using Web-based tools such as Weblogs.

Historic towns and other cultural heritage sites may benefit from fostering online communities of people who share an interest in the town and region. Images and stories of visitors, including testimonials, could greatly enhance the vibrancy of a historic town's online portal or, more likely, a related Web site. Furthermore, user-created content may provide clues for enhancement of experiential value and visitor management. However, for most towns and cultural heritage sites the challenge will first be to embrace the idea of co-operating with a (non-professional) online community, and then to nurture an evolving and thriving community that crosses virtual as well as physical space.

Recommendation: 5.5 Evaluate the effectiveness of cultural routes and electronic tour guides in attracting and retaining tourists

Cultural routes can attract tourism to a region and important nodes such as historic towns. They can also be used to link up a town with interesting places in the surrounding area. In this context, electronic tour guides provide an interesting opportunity to explore for use in historic towns and sites. Such guides typically offer visitors different thematic entry points and suggestions for tours around the town and attractions and routes in the wider area. They provide information about places and objects, what to look for specifically, etc. The opportunity for visitors to capture and share content (e.g., URLs) with mobile devices could also help promote the town and region to others.

In the last two decades there has been a boom in cultural routes and trails ranging from major routes that are acknowledged under the cultural routes programme of the Council of Europe to many lesser-known regional routes and trails that have been developed for capturing tourist interest. However, little is known about the effectiveness of cultural routes for attracting and retaining tourists and the role that ICT applications such as electronic tour guides play in this.

Recommendation: 5.6 Leverage the experiential value of on-site ICT applications for presentation and interaction

On-site ICT applications for presentation and interaction at heritage sites often only have the role of an 'add on'. Little consideration about the experiential added value of on-site installations will often mean that they are underused, although the cost of maintaining them is considerable. However, very little is known about the total cost of ownership of such applications compared with their attraction value and experiential benefit for visitors.

What is clear, though, is that ICT applications for on-site presentation and interaction must fulfil many requirements. In particular, they should be easy to use and understand; engaging and inspiring, allowing visitors easily to learn about the heritage site and artefacts; based on advanced technology and high-quality content, but mature and stable; manageable by the site's staff, who cannot be expected to have experience in computer programming. Furthermore, with a view to a wider adoption in the sector, ICT applications should be deployable in different environments and available in a range of costs.

What also must be recognized is that the visitors will become increasingly demanding. Visitors' measures with respect to ICTs and media experiences are set by leisure and entertainment offerings that are often created by teams of highly skilled professionals with large budgets. Heritage sites will need to concentrate on enhancing the experiences of visitors and imparting cultural knowledge in novel ways that involve the visitors. This is not an argument for turning cultural heritage sites into entertainment venues but a warning that offerings that do not invite, inspire, engage or immerse will not find a wide appeal.

Recommendation: 5.7 Consider participation in research and development of ambient intelligence environments for historic towns and sites

A field of future ICT applications for experiential benefits is ambient intelligence environments. Such environments will comprise wireless, sensor and other technologies for seamless outdoor–indoor communication with location-based, user context-aware information services, not only for historical information, but also for promotions, e.g., retail or events. Personalized virtual tour guides would be capable of appearing on the screen of any interaction device, e.g., mobile, outdoor displays, shop windows, etc. Information would be provided and stories told according to thematic interest in streets, squares, buildings and other locations, and visitors and locals be invited into buildings or to provide own digital images and comments.

Recommendation: 5.8 Make use of available and emerging applications for experiential positioning, planning and development

ICTs will also play an increasingly important role in regional and urban planning and development. For example, a large part of regional and municipal planning tasks are already supported by geo-spatial information and GIS applications, which are also expected to allow better understanding of environmental, economic and socio-cultural dynamics. There are also many IT-based tools that can be used in 'placemaking' projects with local communities.

Particularly interesting would be applications that support experiential positioning, planning and development, including stakeholder participation. Such applications could support development tasks such as asset identification, trends and competitor analysis, and definition of a distinctiveness strategy (e.g., based on an 'experiential benefits SWOT' of a town). Furthermore, predictive modelling, simulation and analysis tools, including analysis of potential impacts, and calculators for investment plans and return on investment for stakeholders would be of interest.

Town-level experience design could be used to define the potential experiences at certain places, including interaction modes and content. A particular goal of such a design may be to develop new experience spaces to move visitors away from already overcrowded cultural heritage areas.

Group: 6 The role of the European Union

Preserving and making use of the rich and diverse cultural heritage across Europe for purposes such as cultural learning and mutual understanding, cultural tourism, regional development and cultural creative industries are of vital interest for the European Union's economic competitiveness, job generation and citizen's quality of life (Lisbon Agenda).

ICT and digitization are providing new opportunities in the management and valorisation of tangible cultural heritage such as monuments, sites and museums as well as content that is held by archives and libraries. For example, traditional and new constituencies can be reached and served in ways that were unimaginable one or two decades ago.

The considerable investment by the European Commission in ICT projects related to cultural heritage has had a substantial influence in building a research community targeted specifically on ICT research needed to support cultural heritage. The results to date have been considerable, but as with many exercises in knowledge discovery, the 'more you find out, the more you realize you don't know'.

There is some way to go to realize the full potential of ICTs in support of the cultural heritage sector. In particular, this concerns effective tools for the use of the digitized and born-digital data and content both for personalized search and research tools and for authoring of relevant, meaningful and engaging interpretations and interactive cultural experiences.

To ensure that the emerging knowledge and experience is taken up and used by the sector will require research in these areas to be backed by a number of support actions and accompanying networking infrastructure. In view of the nature of the sector, which is made up mainly of 'social enterprises', it is certain that these measures will require public funding to make them effective.

In this research agenda we have explored a range of topics related to the inter-disciplinary research required to realize the potential benefits of ICTs in support of the many professional roles in cultural heritage. In this final section we conclude with some observations on the justifications for European Union-led support of the progression of this agenda. There are clear reasons for such support:

- Cultural Heritage within the European Union does not recognize national boundaries. The links between the heritage of different states of the Union span migrations of ethnic groups, changing political boundaries, trade links, developments and spread of technologies, cultural influences and the spread of design styles, along with the inter-cultural influences and freedom of movement within the EU of today. It is clear that national investment in techniques appropriate to particular elements of heritage will have significance well beyond national boundaries. The fact is that benefits of such investment are unlikely (for example) to include the development of a purely commercial new industry sector which an individual nation might exploit through exporting skills. It is therefore appropriate as a European investment.
- The Cultural Heritage Sector and the organizations that support and use it have a less commercial, but socially valuable mission. Many of the enterprises involved (including many of the SMEs) would be better classed as 'social enterprises' than as 'profit-motivated', yet the sector as a whole is of very significant economic importance to Europe. If the sector is to grow healthily then investment is needed in the support infrastructure for these 'social enterprises'. Organizational development, technological infrastructure, access to specialized expertise, shared best practices and market intelligence are just some of the aspects that would benefit from a systematic, Europe-wide, support infrastructure.
- Individual national research initiatives seem to accept the 'purist' view that the most valued research should be unbridled by limitations imposed by consideration of usefulness. In part this appears to arise from the perceived need to have national research capability evaluated as at the forefront of international levels – measured using the same underlying philosophy of what counts. In fact, this tends to devalue the interdisciplinarity that many claim to be rising in priority. The framework programs of the EU have in general been rather better at valuing use-inspired basic research, possibly because European Union programmes are less about national advantage than about mutual benefit.
- One of the major barriers to integration of European digital cultural assets arises from the lack of widely-used standards and relating to this the lack of sufficient appreciation of the implications of cultural diversity for ICT systems. These needs are reflected in the current lack of multi-lingual and multi-cultural thesauri, taxonomies and ontologies and in the multiplicity of national documentation standards in use. A Europe-led initiative is much better placed to ensure the definition and adoption of international standards (e.g., CIDOC-CRM).
- Individual member states tend to have national self-images which are less culturally diverse than the European Union taken as a whole. Promotion of a culturally diverse, but multi-culturally aware, society is a healthy objective for the Commission, but many of the more challenging research topics relate to the difficulty of achieving ICTs capable of personalized multi-cultural responses to queries. Research in this area must be suitable for European support, and is actually considerably longer term.
- A rather more obvious and immediate reason for the topics raised here to be supported at European level is that only continued investment in research in these fields can enable organizations to deliver on the vision of the European Digital Library, both in the area of mass digitization of the full spectrum of cultural artefacts and their metadata and in providing appropriate access and exploitation of digital cultural assets.

Recommendation: 6.1 **We recommend that for the many reasons given in this document the European Union continues to co-fund both use-inspired basic research in ICTs to support potential Cultural Heritage applications and applied research to realize the potential in application areas that have demonstrated this potential.**

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