DigiCULT

New Technologies for the Cultural and Scientific Heritage Sector

Technology Watch Report 1

Information Society Technologies

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New Technologies For the Cultural and Scientific Heritage Sector

DigiCULT Technology Watch Report 1

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Introduction

The *Digital Culture Forum* (DigiCULT Forum, IST-2001-34898) monitors and assesses research and technological developments in and for the cultural heritage sector in Europe. DigiCULT received support from the European Commission's Information Society Technologies (IST) Programme under the 5th Framework Programme. It is not a new initiative. It is the successor to a strategic study commissioned by the Cultural Heritage Applications Unit of the European Commission's Directorate General for the Information Society.

DigiCULT's 2002 report, *Technological Landscape for Tomorrow's Cultural Economy* investigated the technological issues that cultural heritage institutions needed to address over the following five years. Acknowledged experts joined discussions to identify the most pressing technological problems memory institutions were likely to face during this period. They recommended political and institutional action required if cultural heritage organisations were to obtain the maximum benefit from the opportunities technology was opening. While it is hoped that readers will have the opportunity to study that report itself, this paper draws attention to several challenges the study showed were facing Europe's institutions. These included the need:

- to provide access to the riches of European cultural heritage by enabling interoperability between its various sectors. This can only be achieved if issues associated with variation in standards and interoperability across these sectors can be addressed;
- to build tools and systems to tackle the increasing volume of material needing to be digitised and maintained in accessible forms;
- to address the technological, intellectual, legal and economic problems related to archiving and long-term preservation of cultural heritage content;
- to unlock cultural heritage resources by offering personalised, highly interactive, stimulating, hybrid environments and shared spaces to foster the construction of cultural heritage content; and,
- to enable players from different sectors and users to participate actively in creating enriched environments for cultural heritage services by building easy-to-use, intelligent, collaborative and highly interactive tools and systems for non-technical users.

Meeting these challenges depends not only on content creation, but also on access to information about technological developments and opportunities.

The cultural heritage sector suffers from a lack of access to accurate, accessible information about current, near- and longer-term technological developments. Furthermore, the sector has no reputable source which reviews the experiences of its institutions as each attempts to take advantage of newer technologies, whether they be methodological, technical, or exploitative.

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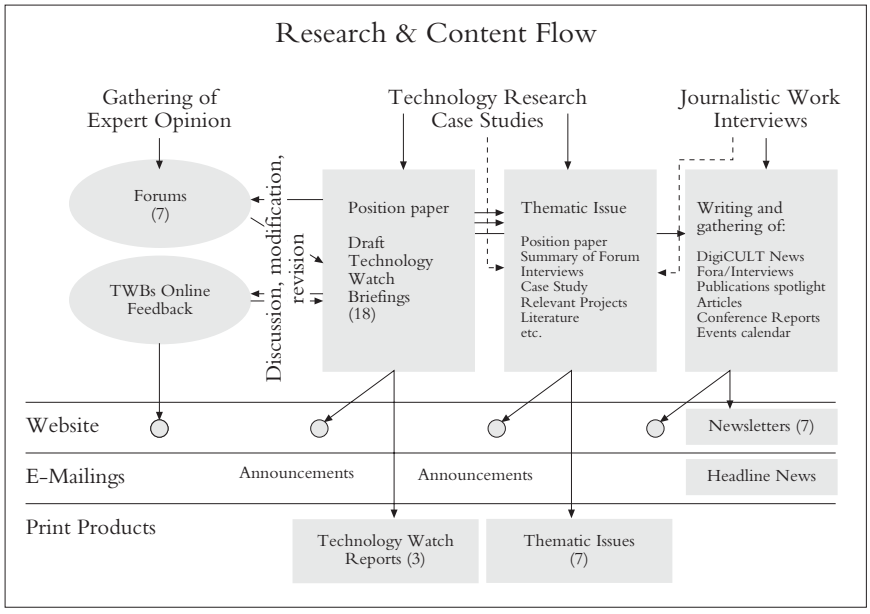
DigiCULT aims to bridge this gap. It examines the changing face of technology to identify developments that could be deployed without further work, those that would require further development or repurposing and those that are still in promising, early stages of gestation DigiCULT's project team recognises the risks of adopting a technology driven approach. It endeavours to balance its over-view of the technologies with the opportunity for the sector to bring forward problems for which they would wish to have a technologically supported solution. As the team reviews developments, it seeks to identify technologies that could help address these problems. Where no solution appears available it endeavours to make researchers aware of specific needs of the sector.

The Technology Watch activities will produce three Technology Watch Reports. These documents will provide accessible descriptions of new technologies, suggest how these might be employed within different cultural domains, and indicate the implications and risks (e.g. social, organisational, financial) of adopting particular ones. In developing its Technology Watch activities, the DigiCULT team is monitoring whether recommendations set out in the DigiCULT study are bearing fruit and whether assumptions about future technological development are actually being realised. By better understanding how technologies are adopted and how successful recent research has been in predicting the impact of new developments, the project team should improve its success at identifying future technologies and making the community aware of them. As this project produces each study it will evaluate its impact and predictive accuracy to ensure that it improves its metrics and practices.

The Technology Watch Reports are only one of four ways in which DigiCULT contributes to improving the knowledge about and the use of technologies within the cultural heritage sector.



- DigiCULT hosts themed fora and publishes their results. So far we have released three of these: *Integrity and Authenticity of Digital Cultural Heritage Objects* (August 2002), *Digital Asset Management Systems for the Cultural and Scientific Heritage Sector* (December 2002), and *XML: Towards an Interoperable Semantic Web for Heritage*

Resources (April 2003). We have four more fora planned; for example, we are hosting one in July 2003 on 'Learning Objects'.

- The *DigiCULT.info Newsletter* has become a vehicle to enable specialists to contribute articles about services, studies, technologies, and activities to a professionally edited and produced online publication. With the February 2003 issue of the *Newsletter*, it moved to publication on a quarterly basis.
- The project website, www.digicult.info, continues to be developed as an increasingly valuable resource for those seeking access to information about events, resources and digital copies of our publications.

Background to Technology Watch Reports

DigiCULT's Technology Watch Reports identify and describe technologies that are either not currently used in the heritage sector or are under-utilised by it. Technologies develop quickly and the heritage sector needs to identify those that will bring benefits and provide a certain amount of sustainability over a reasonable horizon. During its initial thirty-month lifetime, the project will release three reports, each examining six core technologies. The reports will provide a technical analysis of each core technology, a description of its benefits and an explanation of how it could be deployed. In preparing these reports we are reviewing emerging technologies, assessing how specific technologies could be used, and establishing problems that the technology might help to solve or new opportunities it might create. The emphasis must, wherever possible, be on the incremental rather than the dramatic.

Throughout the work, the DigiCULT project team uses the word "technology" in its broadest sense to cover methods (e.g. modelling and data representation strategies), procedures, standards, hardware (e.g. mobile phones, 3D-imaging technologies), and software applications. New technologies are emerging at a phenomenal pace and there is no shortage of technologies that either appear or purport to have value for the heritage sector. So, the problem is not identifying new technologies to review but selecting those that are most likely to have a positive, significant, sustainable, measurable, and cumulative impact on the cultural heritage sector. A key issue will be ensuring that the technologies selected for review do not quickly become obsolete. One needs to remember the CD-I technologies adopted with great excitement by the heritage sector in the late 1980's only to disappear very soon thereafter. CD-Is were left holding materials that appeared to be inaccessible, such as the BBC's Domesday Survey. The process of selecting technologies is, therefore, a complex and risky one.

Emphasis has been placed on technologies that have been proven in other domains and can be transferred to the heritage sector with minimum risk of failure or "infant obsolescence". There are many technologies that could bring value to heritage institutions and to ensure that the sector makes the best selection of those that can be covered the project team used the following questions to compare different possible technologies:

- Has the technology proven its value in other domains?
- Does it have clear applicability to the heritage sector? Are there scenarios that clearly demonstrate its potential?
- Is the technology likely to enhance access, use, understanding, conservation, and/or preservation of the cultural heritage? Will it improve the visibility, use, or management of heritage collections?

- Will it enable institutions strategically to improve their use of computer- and online-based technologies to exploit their assets?
- Is it likely to have a lasting impact on the heritage sector?
- Can the technology be exploited by different sizes and types of cultural heritage institutions?
- Will the impact of the technology be measurable?
- Can the technology be brought into use easily?
- Is the technology stable and pervasive?
- Is the technology going to improve delivery of service?

The approach is mainly technology driven. In some instances these reports will cover technologies that could readily be applied to the heritage sector. Others will identify technologies that could be used to address heritage sector challenges such as information management, ensuring public access to information resources, management and delivery of services. Yet others will facilitate work within the sector. The project team recognises the risks of adopting a technology driven approach to a selection of topics and is balancing its strategy with consultations encouraging heritage cultural professionals to bring forward technology enabled solutions to their challenges. As the team reviews developments it will seek to identify technologies that could help address these challenges. Wherever possible, it will make technology developers aware of specific needs of the heritage sector where they cannot be met by the current generation of tools.

During its initial thirty months, DigiCULT will review eighteen technologies. Using the selection criteria outlined above, DigiCULT's original Partners (HATII, PriceWaterhouseCoopers, Salzburg Research,) and its Steering Committee (see Acknowledgements) drew up a list of technologies which would be the focus of the first twelve studies. This report covers Customer Relationship Management Systems, Digital Asset Management Systems, Virtual Reality, Human Computer Interface technologies, Smart Tags and Labels, and Games. The report to be released early in 2004 will cover:

- the XML family of technologies;
- technologies and new socio-economic business models including rights management technologies and automated payment systems/mechanism;
- application service models;
- collaboration and virtual communities;
- mobile access to cultural institution information resources; and,
- cultural agents and avatars, electronic programming guides and personalisation.

The Methods of Working

Once we have made a preliminary selection of the technology we begin an evaluation and analysis of relevant information resources, consulting reports online materials, research reports, standards, and technical guidelines. Special emphasis has been given to the review and appraisal of research and development projects funded by the European Union such as the Fifth Framework Programme, National Science Funding Programmes (NSF) in the US and other national projects in Europe, North America and Australasia. Interviews provide a valuable opportunity to add depth to understanding of the issues and to identify and cover topics that have not been adequately addressed in available literature.

Each Technology Watch Report contains several scenarios and case studies. These aim to make the reports accessible and useful to as wide a segment of the cultural heritage community as possible. The scenarios are presented in narrative form, but have been constructed around some basic principles. Each contains:

- a description of the institutional context (e.g. categories of institution, size, type, location, and visitor numbers) on which the scenario focuses;
- the problem that the technology aims to address or the opportunity it is intended to create;
- the policy or organisational framework necessary to ensure the technology's successful adoption;
- a description of the technology as understood from the perspective of the institution or key player using it;
- the staff context necessary to ensure that new technology is appropriately adopted;
- any special challenges or risks encountered in the adoption of the technology; and
- a clear description of the benefits that institutions have achieved.

While desk-based research and contextualisation of technology through scenarios is helpful, interviews and case studies are even more so. Interviews provide a perspective on a given technology that is often lacking from the printed and online literature. Interviews were conducted by telephone or, occasionally, by focused questionnaire sent to institutions that already had implemented a technology. In each case, information was sought about:

- What problem the organisation felt needed to be solved;
- How the technology was selected;
- What strategies were used to sell it within the organisation;
- What obstacles had to be overcome before it could be adopted;
- How successfully had it been implemented;
- Whether anticipated benefits had been achieved;
- What risks were anticipated and which were meet;
- What, if any, alternative processes had been considered and why they were rejected;
- What existing (e.g. internal) resources were tapped to ensure that the introduction of the technology was successful;
- What additional resources had to be brought into the organisation to ensure the technology was adopted;
- What lessons the organisation learned in the process and what would it do differently if in the future it were to introduce another new technology.

To ensure consistency of quality and approach, production of the briefings that combine to form the Technology Watch Reports are broken into six stages:

1. Following the identification and scheduling of the topic, we seek advice from the DigiCULT community to help us identify published and unpublished materials, to determine which, if any, institutions are already using a technology and to obtain recommendations from other sectors where it has already been applied.
2. Desk-based research is conducted to develop a profile of the technology, establish how it works, define its current use in other sectors, assess benefits it has brought, determine how it can best be transferred to the heritage sector and establish what the cost and training implications of its adoption might be. This stage involves discussions with technology manufacturers, users and developers.

3. Once the profile is complete the research team conducts interviews with sites that have been using the technology. We use these interviews to produce case study evidence. These provide information about, for example, the process of introducing the technology and details of the impact of the technology on the institution, its staff and visitors.
4. Where the technology is not generally in use in the heritage sector or a sub-sector, scenarios are drafted to show how it might be used and the kinds of benefits that it might bring.
5. Before release, each section of the report is reviewed by DigiCULT partners, at least one member of the steering committee and other independent experts.
6. After this initial internal review, each briefing is made available for comment on the www.digicult.info web site. Comment on the report is actively encouraged from members of the cultural heritage community and technology specialists.

Because we recognise that many institutions do not have access to technical support services to help them to assess technologies the reports emphasise the quality assurance processes in their production. At the outset, the technical sources are selected for their relevance, the significance of their contribution, their accessibility and availability, the clarity of their presentation, the transferability of the examples that they describe and an assessment of the credibility of the authors and their institutional or organisational background. Where online literature is used preference has been given to that which is held on sites with archiving strategies or that are managed by major research institutions likely to curate their digital assets and ensure their long-term availability.

Interviews and questionnaires are used in developing technology assessments, and therefore the necessity to involve only appropriate and credible respondents is recognised. Experts are sought with the following characteristics:

- familiarity with the information and technology sectors;
- knowledge of technology and the process of its introduction into a sector for the archives, libraries and museum arenas;
- experience-based knowledge;
- aptitude in describing the specialised role of an organisation and its policy making frameworks; and,
- skills at explaining the role that technology can play within the heritage sector.

Scenarios are tested to ensure that they offer readers easy ways to understand how a technology meets the needs of their community (organisation). Each scenario is checked to ensure that it:

- is easily understandable and has an adequate contextual setting;
- is contextually real (i.e. that it is appropriate and likely);
- reports benefits of the technology that are appropriate to the category, type, and size of institution which is the focus of the scenario; and,
- is not too temporally bound, i.e. that the problem, solution and context will still be real in three to five years and that the solution will still be at the cutting edge in the medium term.

Shape of the Technology Watch Report

This Technology Watch Report includes six chapters, each of which is identically constructed. An *Executive Summary* sketches the technology in questions and the benefits it will bring. It is designed to give a senior, not necessarily technologically skilled manager enough information to be able to decide whether the technology has a place within the organisation and to ask questions that will promote understanding of the technology. This is followed by an *Introduction to the Technology* which describes how and where it is currently used and what sorts of problems it is used to address. The next section, *How Does It Work*, looks in more detail at the underlying technology, establishes its workings and examines its benefits and risks. Appreciation of the technology is developed further through case studies and scenarios, *Application to the Heritage Sector*.

A major problem with technology take-up is the process of introducing it to the organisation. The section *How do you Introduce the Technology* considers the process by which technology can be adopted and deployed within an institution. It covers the policy and organisational framework, the existing technology infrastructure required to enable the technology to be adopted, the kinds of information resources or organisational structures to make the technology appropriate and, where appropriate, considers the level of staffing and the kinds of user-base. Supplementary documentation includes details of relevant technology suppliers or developers and references to printed and online technical resources that the reader may find helpful in planning the implementation of a particular technology.

It is hoped that, after reading each of the chapters in the Technology Watch Report, readers will be familiar with:

- the nature and capabilities of the technology;
- how it works;
- how the technology can be applied to the heritage sector;
- what benefits it will bring to different heritage communities (e.g. for some a particular technology may have little value, but for others its impact might be critical);
- what obstacles are there to deploying the technology in the sector;
- what risks the technology may pose (e.g. financial, staffing, management, training);
- which organisations have adopted the technology and what benefits they have obtain from using it;
- what evidence do the case studies provide that might encourage widespread adoption of the technology; and,
- who are the main providers or developers of the technology.

The Technologies Covered in this Report

Information, Communication and Technology (ICT) and especially computer-based tools, play a central role in the creation, collection, storage and dissemination of heritage information. This is beginning to have a profound effect on patterns of information use and communication. Significant improvements in technology are enabling the heritage community to make better use of information technology. Advances in hardware and software have been accompanied by progress in other technological and methodological areas that increase the complexity of the data structures modelled and the categories of data that computers can handle. Several of the technologies examined in this issue reflect these developments.

Cultural organisations recognise that, just as in most commercial businesses, they need well-managed information about customers if products are to be responsive to their interests and needs, if they are to keep their customers informed about new offerings, encourage them to take an interest in new offerings and target new products to their customer base. A detailed, well-maintained database of current customer relationships can be exploited to extrapolate trends and anticipate future patterns activity. In the past, institutions have often been able to collect such information only at an aggregate level. Increasingly, now, they are accumulating greater amounts of information about individuals. Software dedicated to the storage, organisation and maximum utilisation of customer information provides the technological part of the solution to use this information effectively.

Customer Relationships

The first Technology Watch Report introduces Customer Relationship Management systems (CRM or eCRM) and demonstrates its relevance to the cultural heritage sector. As well as helping organisations maximise profits and maintain their competitive edge, CRM software can reduce duplication of effort, contribute to the elimination of contradictory information, make information accessible across the organisation and allow organisations to present a unified. personalised face to customers, patrons, partners and visitors. Essentially, CRM's enables an organisation to provide a better level of customer support and target its products or services more accurately. It can also increase revenue from existing customers, exploit previously under-utilised resources and reveal potential business opportunities. To do this organisations need to know more about their visitors and users and to use that information to develop stronger relationships with them.

Smart Tags for Objects

The management of objects also plays an important role in the activities of archives, libraries and museums. Here again, newer technologies can improve the efficiency with which this is done and enable institutions to offer users services that have not been possible in the past. Systematic tracking makes it possible to move and store items more efficiently, a solution to a problem that poses logistical difficulties for any organisation that handles substantial quantities of material. Key to this process is the ability to link an object to its digital record. Barcoding, a well understood and cost effective technology, has become the most common way of doing this, although its limitations do not necessarily mean it is the best. As the third Technology Watch Report makes evident, labels called *smart tags* using radio frequency identification (RFID) technology, provide an alternative. Smart tags do not suffer from the limitations of orientation and distance intrinsic in barcodes. They minimise human intervention, can store more information locally and can be reprogrammed. This technology uses radio frequencies to read information on the *tags* fixed to or embedded into an object or its container. They either reflect or retransmit radio-frequency signals and, like barcodes, can be linked to databases such as library catalogues or museum collection management systems. As well as being used to improve the handling of the objects themselves, they can be used to manage visitor or user access to information about the objects. The technology requires some investment, the tags themselves are more expensive than barcodes and standardisation of the tag data structures has

not yet happened. But the technology has been adopted by a number of cultural organisations to improve traditional work processes such as check-in, check-out, anti-theft control, inventory and asset management. Once the tags are in place they provide a foundation for innovative ways to provide users with access to information about holdings and then collect information about how users interact with holdings. For example, libraries and museums can improve inventory management and visitors to these institutions can use tag readers to to draw information directly from the collection management system.

DAMS for asset management and online visibility

The European Commission and its member states are encouraging digitisation of cultural heritage material to improve online visibility of the European cultural and scientific heritage. As institutions invest in creating digital content or acquire content that only exists in digital forms, as archives increasingly discover they must, they need access to better technologies for tracking, exploiting, and repurposing digital assets. Digital Asset Management (DAM) systems support the acquisition, description, tracking, discovery, retrieval, searching, and distribution of digital assets. The second report outlines the technologies which underlie a standard DAM system and highlights how it can be used by cultural institutions to facilitate the most efficient and effective use of digital assets. It is unusual for individual cultural institutions to have the technological infrastructure or the experience needed to treat these digital materials as renewable and manageable resources. The decreasing costs of implementing DAMS technology make this feasible for institutions of nearly all sizes.

The Human Interfaces

The interface between person and machine represents a major stumbling block to the successful use of computer tools, but it is an exciting area of research that is promoting new developments in human-computer interaction (HCI). A wide array of devices, providing different modes of interaction based on different underlying concepts is coming into commercial use. The design of these devices reflects the needs and abilities of users, the range of human senses, from hearing to touch, that can be harnessed and recognition that portability is essential. The diversity of devices coming to the market is dazzling, so the fourth report only describes those that are likely to have the maximum impact in the heritage sector, applications including head-mounted displays, shutterglasses, CAVES, speech input systems and wearable computers. New methods of human computer interaction make it possible for cultural institutions to provide visitors with dynamic and immersive tools for observing collections not currently on display or with mechanisms that can give tactile and weight sensations while they "virtually" hold fragile and restricted access items. HCI processes allow users to navigate through collections in ways never imagined before. The "electronic nose", for instance, could help monitor collections and sense changes in their condition. This might be especially valuable in the case of film collections where early identification of "vinegar –syndrome" is essential and currently require high levels of human intervention. While some of these novel interfaces can be disorientating, others open collections to the physically challenged that have never been accessible before. Future improvements at the interface between person and machine will

focus on multi-modality, easier use and more immediately reactive interfaces. For the cultural heritage field this will mean a broadening of the group of perspective users and more natural communication between user and computer system.

Virtual Reality for Heritage Access & Understanding

While Virtual Reality (VR) applications depend upon the interpretation of vast amounts of heritage data, they can be used to allow the general public to visualise the past in ways that are not feasible with conventional presentations. In theatre studies (e.g. the THEATRON Project) and archaeological reconstructions of completely or partially destroyed structures (e.g. The Roman bath complex at Bath) VR technology has been used to great effect. As it becomes more accessible, it offers great potential for visualisation of heritage sites, landscapes, and buildings. These visualisations permit the user to "move" through the environment and see it from various angles. Using archaeological data, databases, static images, and 3D interactive models, VR can bring to life data which are otherwise difficult to put into context. For example, it can be used to hang a virtual exhibition or to show how an historic building or landscape has changed over time.

Computing hardware and software have advanced to a point where it is possible to construct and view models using personal computers. Further technological improvements will soon enable these models to be immersive, interactive and involving. Developments in the speed of networks make it feasible to deliver these models over the Internet. For example, Virtual Reality Modelling Language (VRML) makes interactive navigation accessible to anyone using the World Wide Web. Thus, users can experience a "virtual" visit to an historic building, an archaeological site, or a landscape. The same tools can be used to create an interface for multi-disciplinary presentations of heritage data, making links between the land, the buildings, the objects in museums, historical documents, and the environment in a holistic way, rather than the current arbitrary division of information areas. If there is a shortcoming to the technology it is that the models can appear too realistic, as for example they appear in the movie *Gladiator*. In reality, archaeologists are often not sure about reconstructions of ancient monuments or at least there are conflicting interpretations. VR models do not always make these differences apparent to the visitor or viewer who may as a result gain an inaccurate impression of the historical record. On the other hand, in VR driven teaching applications the faithfulness of the virtual environment to the historical record may be of secondary importance if the system improves the speed and depth at which students learn.

Games for "edutainment"

Play is a fundamental human activity and an important way to learn. Cultural institutions do not take sufficient advantage of games to expand awareness and knowledge of collections through "edutainment" packages and other strategies. In our discussion of gaming we concentrate on console and computer games as these presently offer the greatest number of possibilities for displaying cultural heritage content. Broadly speaking, the term "gaming" covers a range of applications running on different platforms, from dedicated consoles to personal computers, mobile phones, handheld game units and arcade gaming machines. The games themselves can be classified by genre, whether they are single or multi-user, the type of delivery device they are designed for (e.g. console versus PC), or whether they can be used online or offline. Improvements in human computer

interface technologies, graphics, and the representation of virtual environments are among the technologies that have contributed to the development of more realistic and versatile games. Since the late 1990s there has been an increase in the number of games set in historical contexts or which have involved cultural organisations in their development. Numerous games that demonstrate potential in the education and heritage sectors are freely available online. The final report in this volume examines gaming technology and its possible role in the heritage sector. Games can provide an exciting way to engage younger audiences with the European cultural and scientific heritage and can make exciting use of digital assets that heritage organisations are creating.

Contextualisation and Next Steps

There are numerous dangers posed by the introduction of new technologies. Among these are over-optimistic expectations, rapid redundancy of hardware and software, shortage and high-cost of support services such as training, and problems surrounding the maintenance of hardware, software and data. The technologies covered in this report all can contribute to improving working practices in public institutions and most can be closely inter-related. Smart tags, for example, provide mechanisms for linking objects with their representations stored in digital asset management systems and supply mechanisms for managing and monitoring visitor experiences. The way in which Virtual Reality representations can be delivered in the cultural environment reflects developments in human computer interface methods and technologies. Games technology is an area that offers substantial opportunities for the cultural sector. Here again, its use is closely linked with DAMS, Virtual Reality, and Human Computer Interfaces. Until recently, design and development costs of games have been a prohibitive factor but, for some uses, newer software development environments have lowered the threshold. While the sector is encouraged to investigate the opportunities that new technologies offer, it should be done with some caution. Six years ago, Riemer Knoop, in an address to a European Union Conference on *Heritage in the Information Age* (Brussels, 5 June 1997) reported that the research showed the Dutch population fell into one of three categories: "(1) thrill seeking/experiencing, (2) inner harmony/escapism, and (3) spiritual growth/intellectual curiosity". The greatest number of individuals fell into the class of thrill seekers. Knoop concluded that if cultural institutions want to maintain their current audience share, "they cannot but adjust themselves to the demands of this group, and to make sure their exhibitions are full of funny electronics, each season new, better, and more surprising" (ibid.). This, as Knoop admitted, is a dangerous approach because it requires continual investment, depends upon access to skilled staff, consumes a steady stream of curatorial resources, is technology driven, and needs to respond to high and ever increasing audience expectations outside cultural institutions. Each year, visitors will expect improvements. Implementing any of these technological developments will require increased resource, whether human or financial. The problem is endemic to heritage institutions where funding of technology has always been sucked from already bone-dry budgets. Rarely have new recurrent monies been made available to ensure that technology is regularly enhanced and replaced (Ross, 2001, *ICT Needs Assessment: 'Budgetary Suicide at the Altar of ICT'*). For technology to find a secure place in museums it must come as new investment. So, while the reports demonstrate that these technologies bring substantial benefits to the sector, they also show that successful adoption and use requires political action to ensure new and more equitable budgets are available to heritage institutions for their implementation.

Customer Relationship Management

Executive Summary

New developments in technology enable organisations to gather a greater amount of information about customers and business contacts than ever before, and provide more efficient ways of managing it. In targeting products and services to the appropriate markets and in developing new approaches to business development data, relating to customers provide an essential tool. Customer Relationship Management software (CRM or eCRM) is dedicated to the storage, organisation and maximum utilisation of these data.

Without an effective CRM solution, customers may have a fragmented view of an organisation, increasing the likelihood of inefficiencies emerging in the organisation's use of customer information and other vital resources. CRM software vendors offer a holistic, pan-organisational approach to the collection and use of this information.

CRM technology is a relative newcomer to the cultural heritage sector, but this report demonstrates that it has much relevance. As well as helping organisations maximise profits and maintain their competitive edge, CRM software can reduce duplication of effort, eliminate contradictory information and present a unified and personalised face to customers, patrons, partners and visitors.

After outlining the basics of CRM philosophy and how it translates into technological applications, this report goes on to detail the specifics of some of the leading CRM solutions vendors. It includes case studies and scenarios of existing and potential CRM applications in the heritage sector, and predictions for future developments in CRM technology, specifically how these are likely to impact on and benefit heritage organisations.

An Introduction to Customer Relationship Management

The problem

An organisation is likely to be comprised of different departments, each of which may conduct different dealings with the same customers. Without an effective and well-planned Customer Relationship Management (CRM) solution in place there is no guarantee that these departments will have effective communications with each other. For example, information held by a customer services department of great interest to the marketing department could remain inaccessible and hence under utilised.

Such a breakdown in communication may lead to customers receiving contradictory information from the organisation. CRM aims to eliminate this by integrating channels to provide a single, reliable *portal* to the data. Another major CRM process is the logging of all customer interactions making them available to appropriate employees. Knowledge of prior contact can help application of a more personalised and unified approach to future customer dealings.

This demonstrates two crucial challenges for organisations: internal cooperation between departments and external communications between business and customer.

The CRM philosophy

Customer Relationship Management originated as a business philosophy designed to strengthen and develop the organisation's relationships. The three central tenets of CRM have generally been the *understanding, anticipation*, and *management* of the needs of an organisation's current and potential customers.[1] The primary motive for implementing a CRM solution is usually regarded as the retention of existing customers.

By understanding more about customers' needs, CRM aims to develop stronger relationships and information networks in order to keep existing customers, and to develop a marketing strategy for the acquisition of new business. Understanding how and why a customer interacts with an organisation is increasingly considered to be of paramount importance. It enables organisation to provide better customer support, to target products or services more accurately, to increase revenue, to exploit under-utilised resources, and discover business opportunities.

Essentially, CRM aims to collate all the disparate information about customer, sales figures, marketing effectiveness and market trends, allowing an organisation to make better use of the valuable data in its possession and gain the advantage of a single, '360-degree' profile of customers across multiple lines of business. The efficient flow of information between different lines of business (LOB's) will show a consistent and unified front to customers, whichever interaction channel, email, letter, telephone, they use to contact the organisation.

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1 Brown (ed.), *Customer Relationship Management*, p. 339.

eCRM technology: putting the CRM philosophy into practice

However, information about customers can be of little use without appropriate tools and methodologies for collecting, storing and retrieving it. Electronic Customer Relationship Management (eCRM) is a technological extension to the CRM philosophy. It integrates many previously separate functions, such as databases, email, word processors, accounts programs and network utilities, into a uniform environment. It allows reliable, accurate data to be passed between different branches of an organisation instantly. The development of dedicated software that facilitates the collection, storage and retrieval of customer data has paved the way for the widespread adoption of more technically advanced eCRM strategies within the business sector, particularly since the Internet boom of the mid 1990s.

Where is CRM technology currently used?

CRM strategy has been most readily adopted by the financial services and telecommunications industries, with consumer goods manufacturers, retailers and high tech firms following close behind. According to Vince Kellen (2002)[2], lecturer in e-commerce technology at DePaul University (IL, US) and CEO of Blue Wolf Consultancy, there are three main uses for CRM systems: i) To influence or validate decision making; ii) To guide ongoing activities and tactics; iii) To predict future sales. Kellen's focus is geared squarely towards the financial sector, but if his list is adapted to fit the cultural heritage sector more closely, it may look something like the following:

1. To influence or validate decision making
Customer-related strategies can have a profound effect on an organisation's customers, and properly established CRM software can provide invaluable feedback on the success or failure of an adopted strategy. Existing customer relationship data can provide some indication of the direction in which the organisation should be heading in order to maintain existing customers and attract new ones. The business strategy will affect how the customer relationship data will be analysed. For example, if an organisation is primarily concerned with return on investment (ROI), it may reach different conclusions to those it would if primarily concerned with less tangible benefits such as customer satisfaction or repeat visits.

2. To formulate procedures
CRM can be of key importance in understanding customer activities on a day-to-day basis, as well as being used in the formulation of long-term strategies. Information about specific customer relationships can be invaluable to customer-facing employees. For example, knowledge of the most frequent types of requests can improve the efficiency of employee/customer interactions and improve customer relations. Such information can act as an invaluable spur in the development of long-term strategy and planning.

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2 Kellen, 'CRM Measurement Frameworks' (http://www.kellen.net/crmmeas.htm)

3. To predict future opportunities

CRM software can act as a useful market research tool, extrapolating trends and anticipating future patterns of customer activity by maintaining, in as much detail as possible, current customer relationships. CRM provides a much closer collaboration with customers, and may provide clues to an organisation on future development. This process is known in industry as 'data mining'.

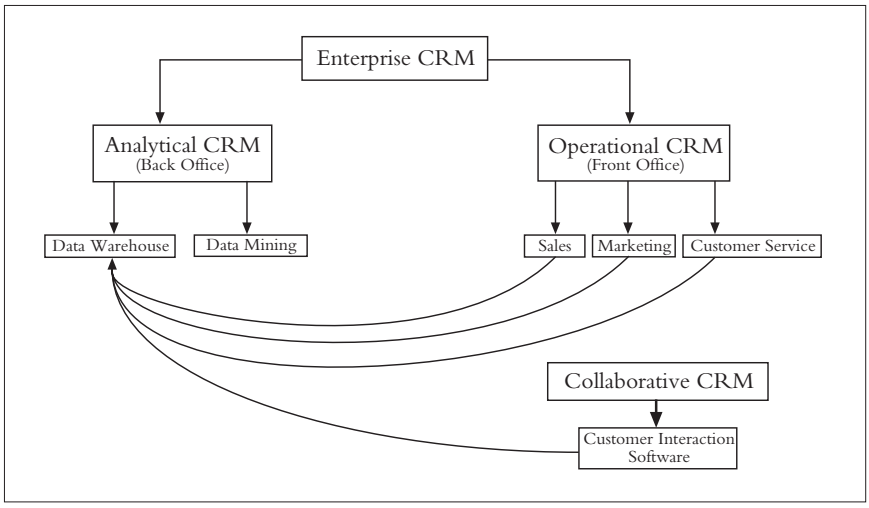
To Kellen's three tenets, a fourth with more immediate and obvious pertinence to the cultural heritage sector can be added:

4. To manage information and maximise client-base potential

A pressing issue is how best to design and target customer information in order to retain existing business, and to entice new business to the organisation. Accurate customer profiling can have a marked effect on commercial business results and this is equally true in the heritage sector. Knowledge of who the visitors/patrons/users are and when and how they are likely to make contact is of the utmost importance in an organisation's strategic planning. If this information can be used to its fullest potential then all concerned should benefit. Many useful lessons can be learned from the business community and, with adjustments to the original focus of most standard CRM packages, it can be clearly demonstrated that, despite the high expense that might be incurred they hold a great potential for the future of cultural heritage organisations.

How eCRM Works

Introduction



Adapted from PricewaterhouseCoopers, Technology Forecast: 2002-2004, p117.

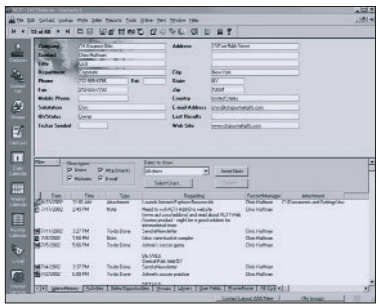
A complete database of customer information is of key importance to any CRM venture. Bespoke and off-the-shelf systems are based upon the same database foundation the shape of which will vary according to the organisation's specific requirements. Even off-the-shelf solutions can be customisable to meet these requirements as closely as possible. In many instances, an organisation will already employ one or more databases to hold information about its clients and customers prior to implementing a dedicated CRM system.

Database structure is crucial to the efficiency of a CRM venture, and the database architecture must be sufficiently robust to maintain all the information that is relevant to the organisation. At the same time, it must be flexible enough to allow numerous and possibly simultaneous interdepartmental queries, alterations and updates to the data. The provision of robust data storage and access is a significant feature of any useful CRM package, but it is the progressive thinking behind its design that makes it such a valuable tool. With CRM, an individual should be able to access any item of customer data before cross-referencing, manipulating or adapting that information to make it functional rather than purely descriptive, dynamic rather than static, and ultimately more responsive – a process of relationship rather than mere atomic transaction. In many cases, these processes will be automated to a significant degree but it must be remembered that *data analysis* cannot be entirely automated. Management must detail what it wishes to gain from the system *before* it is introduced.

Bespoke Solutions vs. Off-the-Shelf Packages

CRM technology suppliers tend to fall into two categories: those who target larger companies and those who target Small-to-Medium sized Enterprises (SME's). The former category of supplier will offer a full and individual CRM solution. This will include a specifically tailored software system, complete with the support network necessary for system maintenance. The latter group is likely to offer a cheaper system (typically costing between €180 and €300 per seat/copy) that promises to run 'out-of-the-box' upon installation, but which will consequently *not* meet the needs of every organisation running the system. Often, a significant amount of 'tweaking' will be necessary in order to integrate a CRM with current technological and organisational practices.

Data Management



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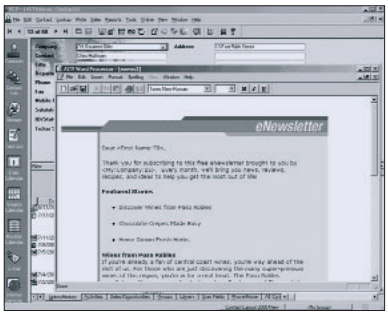
Database architecture and design are fundamental to CRM software. All of the data that are to be maintained will be held within a database (or linked databases). The design must therefore be flexible enough to hold all of the information that is pertinent to an organisation or a particular department and to the relationships in which each is involved. It must be capable of executing the sorts of queries which the employees and customers will find useful and support the storing and further analysis of the results.

The User Interface

The front-end software will vary according to the requirements of the organisation. The CRM environment with which employees interact is usually **Microsoft** Windows based. But some packages offer a Web-based front-end in addition to or in place of the familiar desktop environment, increasing the scope of the system to cater for mobile and remote operatives. Most packages allow for such functions as data input, data update, data query, and the generation of statistics to analyse and isolate business trends. The majority of CRM software packages are compatible with email packages such as **Microsoft's** *Outlook*, whose address book calendar and task list are increasingly essential to eCRM. A dynamic log of customer contact with the organisation should be held; this could give telephone-based staff access to details of email enquiries and other previous contacts with the organisation, thereby assisting them in quickly contextualising the customer's call.



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Integrating legacy systems

Characteristics of popular and effective CRM packages include information sharing between different LOB's, allowing data from existing packages to become increasingly applicable and serviceable within a CRM context. An example of this is **OnContact's** *CRM* software, which incorporates bi-directional integration with *Outlook*.

The overall structure of the organisation therefore becomes increasingly integrated, encouraging cross-fertilisation of information held between databases. A more dynamically accomplished and synergetic outcome should follow. Through these networks of information a CRM makes data that were previously hidden from view available to a range of user communities within organisations.

Hosting CRM applications

CRM software may be held in one of three ways: on the client's own computers (the approach on which all previous discussion has focused), on the vendor's side (ASP-based), or as a combination of both (MSP-based). Server-centric, ASP-based vendors such as **PeopleSoft** allow customers to 'rent' their CRM applications, and the software and data will normally be held securely on a remote server. This approach is popular among smaller organisations that have less, relatively uncomplicated data to store. Although rare, one major risk is that a host company may collapse taking priceless data down with it. Contingency plans must be put in place for such an eventuality. The option to upgrade to a more involved package may be considered where an organisation wishes to begin operating beyond its current sphere. Essentially, the risks of CRM must be carefully weighed against financial savings made from its use.

Organisations wishing to take a more cautious approach may opt for MSP-based CRM, with its increased potential for customisation and consultancy service in addition to standard software-hosting duties. Larger consultancies such as **Cap Gemini Ernst & Young** have begun offering MSP-based CRM solutions, thus significantly shifting the focus away from the technological issues back towards the original business strategy. Analysts repeatedly stress the importance of effective strategic planning above blind technological investment.

Future developments in eCRM

Vendors have a tendency to be tight-lipped when it comes to revealing the specific technologies at work within their CRM solutions. Most packages boast the same features and comparisons between them are usually based on performance measurements rather than additional features. As a result, keeping technical information secret is vital if the vendor is to remain in competition. An increasing number of vendors, including **PeopleSoft** and **Firstwave**, are utilising *XML*, often in conjunction with *Java*, so that customers can tailor solutions to meet their individual needs. If an organisation chooses a vendor that uses *Java* architecture, it can develop reusable *JavaBeans* to integrate an existing system. Mixing multiple vendors with a range of compatible technologies thus becomes an increasingly attractive option.

'Plug-and-play' components enable organisations to prioritise the CRM services they require, to introduce them gradually, and to vary the services across different sectors of the organisation. Vendors who previously offered only complete bespoke packages have come to realise that companies are less likely to pay out huge amounts of money without first conducting a rigorous process of needs analysis, and developing a timeframe for gradual integration. The focus, now more than ever, is between return on investment (ROI) and measurable improvements in transaction speeds, accuracy and customer satisfaction. In terms of getting the right information to the right people via the right medium at the right time, **Instant Messaging** (IM) software is now beginning to come into its own, with an organisation as large as the US Navy using an IM system to connect over 300 ocean-going vessels. IM uses the concept of 'presence' to determine which of a user's available devices has been most recently used and sends urgent messages to the device where the message is most likely to be seen. The compatibility of *IM* software with a huge range of different devices, from desktop PC's to wireless PDA's and WAP applications, means that no matter where in the world a contact or customer is, there will usually be a way of getting that essential message through.[3]

Global solutions companies such as **SAP** are now offering CRM modules as part of an overall strategy.[4] This modular approach is felt by many to be the CRM wave of the future.[5]

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3 See IEEE Spectrum, November 2002 for much more on the potential benefits of Instant Messaging.

4 In SAP's case, CRM is one of eleven mySAP solutions modules available.

5 Source: Denis Pombriant, Research Director in CRM, Aberdeen Group. (http://www.cio.com/archive/050102/crm.html)

CRM Technology and the Heritage Sector

Brief Background

At the time of writing, the majority of CRM packages remain dedicated to the pursuit of increased profit, the idea being that a thorough knowledge of customers leads to increased customer satisfaction with the standards of service that a company provides, thus begetting stronger customer loyalty and longer-lasting relationships. The heritage sector is traditionally involved less in the acquisition of monetary capital through sales (though issues of finance are changing this) than it is in such areas as education, conservation and entertainment. Competition in the heritage sector tends to be less cutthroat than in the world of business, and cooperation is generally friendlier and governed less by returns and base figures. However, customer/patron/visitor satisfaction remains an important factor, particularly when it comes to the sometimes elusive goal of repeat visitors. The pursuit of this prize is among the more pressing reasons for cultural heritage organisations to consider putting a dedicated CRM system in place. Relationships with project partners and funding bodies can be made to flourish with a new approach to CRM.

Case Studies

Case Study I – SCRAN (www.scran.ac.uk)[6]

The **Scottish Cultural Resources Access Network** (SCRAN) contains one million media resources, liaises with 450 partner organisations and has around 28,000 customers and registered subscribers. Prior to the implementation of its dedicated CRM system, three project officers liaised with SCRAN's partners. As a 'small' organisation it was felt that this allowed for a personalised approach, assuming that the relevant officer was present in the office whenever contact was required.

Interim points and deliverables vary for each project partner and keeping track of the status of individual transactions can be difficult. Before the advent of CRM software, the project officers worked from a paper-based filing system, and unlinked and non-standardised databases, although their computers were networked to a server capable of hosting a large, centralised database. No formal contact log was kept. It was decided that a CRM package would moderate registered user communications, ensure data validity and reliability, and manage sales of the main products, namely SCRAN CD-ROMs and online subscriptions to the website.

Graham Turnbull, SCRAN Publishing Manager, had prior experience with **ACT!** CRM software, and was already aware of its capabilities and potential use to SCRAN. A copy of the latest **ACT!** demonstrator was acquired and examined by Turnbull and the in-house technical staff, each noting the potential benefits of SCRAN for both customer-facing and back-office staff. These noted benefits were eventually used for staff training and to 'sell' the CRM idea to SCRAN's management.

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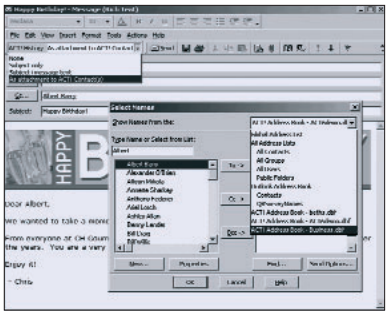
6 This case study is based on two telephone interviews with SCRAN Publishing Manager, Graham Turnbull, which took place on 24/09/2002 and 15/10/2002.

As is often found with the introduction of new and unfamiliar technology, staff and management were initially resistant to the proposed changes in their working practices. Staff feared that the changeover would involve a great deal of tedious work for little tangible reward, and managers feared loss of control over business processes and strategy as a result of an increase in automation. The personal touch that defines SCRAN's dealings with its contacts needed protection, and staff members were initially unsure that this feature could survive the introduction of standardised practice. In order to allay the staff's first fears, a temporary worker was drafted in to begin the process of transition and to perform much of the tedious and often difficult data conversion, verification and alignment.

Implementation and training was completed in-house. This saved an estimated £5000, effectively halving the total cost of the system's introduction. All in all, from planning to final implementation the SCRAN installation took six months, a portion of which involved staff doubling up on both the old and the new systems.

Configuration of CRM software is one of the key issues for all but the smallest, simplest of organisations, organisational simplicity and standardisation being rare in the heritage sector. It must be planned thoroughly and implemented carefully in order that the system meets its potential, justifies its expense, and is workable by users of any existing system. It has been estimated that without the existing in-house experience with the **ACT!** software package, the total rollout time could have been doubled.



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The principal benefit to SCRAN of the new CRM software is the ease with which reports can be created. A variety of monthly and quarterly reports must be produced, and **ACT!'s** calendar system is able to track both scheduled and actual dates of transactions and tasks, as well as managing slippage between segments on the reporting timeline; for example a report that must take into account certain transactions made just outside the calendar month. Patterns and trends can be made more accessible through their presentation in visual form, cutting down on analysis of figures and providing a more intuitive interface between management and statistics, thus easing the strategic planning process. Product distribution can easily be tracked. For an organisation such as SCRAN which has significant dealings with local authority education departments and their central ordering systems, this cuts down on lost and wrongly-delivered products and the frustration of tracking them down.

One additional (and largely unanticipated) benefit to the SCRAN back-office staff was the suitability of **ACT!'s** reports for auditing. Before the introduction of CRM, auditors had to wade through voluminous paper records, but the **Deloitte & Touche** auditors were more than happy to accept the **ACT!** system as an auditable structure in its own right. This had the bonus of acting as an *external* validation of the usefulness of the system, further easing the fears of the staff.

As previously mentioned, the staff's initial reservations and fears regarding the introduction of new technology were perhaps the greatest obstacle to overcome in the CRM implementation process. Once staff members were made aware of the benefits offered by **ACT!** – particularly its potential for eliminating dull and time-consuming tasks – these

fears disintegrated. The fact that Turnbull had experience and faith in the software, and was capable of carrying out the configuration and training processes himself, was a great help.

Among the lessons learned from the CRM implementation process was that it can be highly advantageous to bring in temporary workers to handle the initial stages of changeover. This protects sensitive staff from potentially difficult procedures, and helps to keep them 'on-side'. The success rate of the introduction of CRM software can be improved when the systems are configured to be as comparable as possible with staff's prior IT experiences, for example relating the features of a package's dedicated word-processor to those of a well-known program such as *Microsoft Word*.

Daily backup must be performed on the central database as part of a contingency plan against potentially catastrophic losses and should become standard business practice when dealing with business-critical information, however it is stored.

Case Study II – The Carbon Trust (www.thecarbontrust.org)[7]

The **Carbon Trust** is a government-funded, business-focused, not-for-profit organisation which occupies a position between government, business and the public sector. It was set up to encourage and promote energy efficiency and low carbon energy supplies in order to support the transition to a low carbon economy in the UK. The Trust provides support for businesses in reducing carbon emissions by supporting technological innovation and encouraging more efficient working practices.

The primary impetus behind the Carbon Trust's decision to introduce a CRM system was the pressing need to collate a variety of different databases into a single, reliable and flexible resource. Part of the Trust's remit is 'co-ordinating and brokering between developing technologies and funding partners', and a uniform resource was required to assist in the management of those contacts.

It took little persuasion to convince the organisation's staff of the benefits and necessity of a CRM system; a directive from the Chief Executive secured its introduction and all-round acceptance. Process analysis was conducted on the Trust's different LOB's, followed by targeted tendering, and from this the shape of an appropriate CRM solution began to emerge.

The Trust decided on a bespoke system that could integrate its Microsoft *SQL Server* databases. Given the nature of the Trust's work and funding set-up, other standard CRM functions such as report compilation and automation were not considered to be major factors in the decision-making process. Compatibility with the existing databases, however, was of key importance. The existing data was scattered across a large number of incompatible databases and had to be standardised in order to be centralised. This was by far the most expensive and time-consuming element of the CRM venture, and the problem was intricate enough to merit the introduction of an external database expert to oversee the changes. A powerful server was required to host the new database structure efficiently. Fortunately, the Trust already used such a server, and this reduced costs associated with the hardware element of the CRM solution.

Foremost among the lessons learned from the Carbon Trust's introduction of CRM technology is that it can be counterproductive to allow staff to set working practices and

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7 This case study is based on a telephone interview with Graham Higley, formerly of the Carbon Trust and now Head of Library and Information Systems at the Natural History Museum, London. The interview was conducted on 15/10/2002.

make technology choices. It is far more efficient to take a prescriptive approach from the start with both software and hardware, and to ensure that working practices and policies are rigorously documented.

It is worth noting the **Natural History Museum**, where Graham Higley is now Head of Library and Information Systems, currently has no eCRM system, but plans to begin costing one. Higley believes that, since the Museum is not 'selling' anything, the benefits of implementing a costly CRM system may be fewer.

However, in terms of visitor satisfaction and all-round efficiency, a carefully designed CRM strategy can be invaluable. As the need to acquire donations figures more prominently in the work of professionals in the heritage sector the need to document the processes by which each donation was obtained will become necessary.

Case Study III – National Museum of Australia (www.nma.gov.au)[8]

The **National Museum of Australia** is a federal government agency, established in 1980 with a mission 'to research Australian history, develop and maintain a national collection of historical material, create exhibitions and programs exploring our heritage and history, and to be accessible to all Australians.' On March 11th 2001, the National Museum of Australia opened its new facilities in Canberra, and within three months it had become one of the most popular visitor attractions in the Australian capital. The Museum website hosts a variety content, including visitor information, digitised images, educational resources and interactive games. It aims to be accessible to a wide spectrum of potential users.

Just as museum exhibits have often been used in the past for monitoring visitor behaviour and interaction, so now the Information and Communication Technology (ICT) department at the Museum seeks to obtain new information about visitors' experiences when they access the Museum's website. These data are made up of the details logged by the web server as individual visitors enter, navigate, and exit the site. But, with no dedicated method for the collection and analysis of such data it is more or less useless for strategic planning purposes. The Museum's ICT manager, Darren Peacock, says: 'In addition to providing an experience of the Museum and its collections for virtual visitors, the website is a place for building relationships with those who do visit in person. In building relationships with these two user groups, the Museum requires comprehensive data to understand their various needs and behaviours.'

Some form of analysis was clearly required in order to turn all the Museum's raw data into a useful and valuable resource. Software and services company **SAS** was given the task of profiling visitors and testing different approaches to site marketing, with the aim of discovering how the needs, behaviours and motivations of different categories of users varied. Other aims were to encourage online users to visit the museum in person and for real-life visitors to access the website. The site traffic analysis provided by **SAS's** *WebHound* tool allowed the Museum's team to track different types of online users, for example first time users, returning users, single hit users, and those who remained on the site for a considerable amount of time. The team has the facility to track the behaviour of the users by monitoring daily and hourly traffic, identifying their needs and assisting the planning team work out how to meet these. Since it is forecast that 80% of visits will be

8 This case study is based on information from the museum's website, and from that of SAS (http://www.sas.com/news/success/nma.html). The pages were accessed on 04/02/2003.

online by 2004, this will become an valuable tool for the Museum. 'It is more than just a source of data,' says Peacock of the new CRM aid, 'but an integral part of the strategy to know the NMA's visitors and to meet their needs.'

Scenarios

Some potential scenarios now follow which demonstrate how CRM may be of use to cultural heritage organisations, both now and in the near future.

Scenario I – Museum

A medium-sized museum is having difficulty in maintaining its lists of friends, sponsors and regular visitors, and in maximising storage and utilisation of the information volunteered by them. The museum's staff are familiar with standard PC applications such as *Microsoft Office* and the *Outlook* email program, but none of the liaison team is comfortable with technologies more advanced than these. In addition to this, different members of the team have been storing conflicting data about the same visitors in independent and unlinked databases. Currently, there is no central mechanism for recording visitor contact with the museum whether this a telephone call to change an address on the museum's mailing list, an offer of a donation, or an email to request further details about a forthcoming exhibition.

The museum's director wishes to implement a system that will standardise and streamline this information. She is faced with many decisions, the first being the choice between an off-the-shelf package and a bespoke CRM solution. It is likely that any decision will be contingent on funds available and an estimation of the complexities of the data to be stored. As these complexities are unlikely to be challenging, the probability is that an off-the-shelf package will meet the museum's needs adequately. The biggest problems forecast are retraining existing staff to use the new system to its full potential, and integrating the existing disparate and sometimes contradictory data.

Scenario II – Library

A large reference library currently uses a database to store details of inter-library loans, as well as the immediate whereabouts in stack or shelf of its resources. This database has been populated relatively recently, using information from older databases, microfiche records, and material hand-written or typed on index cards. The library's director has been in the job a long time, and is reluctant to authorise yet another migration of information to a new tracking system, feeling that the current system works perfectly well.

Using CRM software to manage inter-library loans would be advantageous to this library. It would enable other libraries to track resources and it could be used to reserve loaned resources when they were returned and to notify customers when items were reserved for them. For this to work efficiently, other libraries involved would need to use the same standard format, such as *MARC* or *Dublin Core*, for storing information about their resources. Integration of communications, databases, and formatting are likely to be among the key issues in this case.

Scenario III – Theatre

A small provincial theatre is looking to increase its visitor figures in order to justify its continuing Arts Council grants and subsidies. Initial customer research shows that a size-

able amount of business is being lost as a result of an old-fashioned box office with only one staff member and one telephone line. When the line is in use, callers receive an engaged tone, and it may happen that an enquiry about a show taking place some time in the future will prevent a booking being taken for that evening's performance. It is possible for customers to book tickets over the phone and then fail to pick them up, resulting in further lost income if the show is sold out.

The advice and experience of a larger theatre is sought, and the decision is made to introduce a CRM package in order to streamline and ease communications with other theatres, funding bodies, production groups, and patrons. Given the modest size of the theatre, a relatively inexpensive, generic CRM software package is selected and installed on the theatre's two computers at a cost of less than €450. Information from the existing paper address books is then entered into a database, although both the old and the new systems are used in the initial stages to ensure that any minor oversights in the CRM development process do not result in lost or compromised information. Booking and seating information are made available online, further reducing the burden on the staff.

It is anticipated that the time needed for the theatre's staff to embrace the system fully will be longer than in most heritage organisations, as technology use has been minimal in the past. However, with careful demonstration and a cautious approach, the visible results of the CRM package should speak for themselves.

Scenario IV – Archive

A city archive needs to keep track of the documents it holds and, for security reasons, the users who request them. Since the advent of electronic and web-based finding aids, knowledge of who the users are and how their needs can best be met has become a key concern. The user tracking process is currently carried out via a simple database and user registration cards, but no systematic cross-referencing is currently possible between the

An Archival Storage Bay at the Swindon and Wiltshire Record Office, UK

two. The archive's paper-based administration is becoming an increasing burden on the archivists, and ongoing activities, such as digital cataloguing, are suffering as a result.

Through the implementation and customisation of a dedicated CRM software package, a new customer database could be linked to the archive's current electronic resources and finding aids, allowing previously-unrecognised patterns to be revealed. The archivists would be able to produce reports which quickly detail, for example:

- which type of user (student, historian, genealogist) requests a given document or set of documents most frequently;
- which documents are most popular (given their uniqueness and the risk of wear and tear, the archivists may wish to consider digitising these);
- how users contact the archive (telephone, email, fax, letter); and
- what geographic areas the enquiries are coming from?

These reports may be produced in a visual format, making the statistical information easier to contextualise, supporting administrative decisions, and making it easier to answer user queries. Many archives offer users a certain amount of searching time (often the first thirty minutes or hour) free of charge but it will be necessary to record all user time in order to administer chargeable elements. Other chargeable services, such as copying documents or viewing building control records, can be streamlined and standardised.

A log of contact instances will be kept by the CRM package, with standard answers to frequent enquiries made available on a basic website. This log could be linked to the report-generating element of the software. The website could allow registered users to view selected documents from their home computers, further easing the strain on the duty archivists. Details of document acquisitions and appraisals can be stored on the system, alongside appropriate contact and legal details for sources and donors.

One difficulty for an eCRM solution in this case is the strong likelihood that not all documents will be digitally catalogued. Card indexes and manual catalogues still hold vast amounts of information. It will be essential to map the current archival description standard format to the CRM database design, in order for the two systems to exchange information accurately and efficiently. Depending on the complexity of the proposed CRM solution, this may be an expensive process, and must be costed rigorously prior to the final purchase decision.

Staff may have to be trained in the use of the new technology, though the fact that archivists already work according to strict procedures and guidelines should be an aid to this process.

The archive's digitisation strategy is slow but ongoing, and is largely based on those documents most frequently requested by users. With careful planning and implementation, the CRM system will be an invaluable factor in informing the archive's future cataloguing and digitisation strategies.

Scenario V – Arts Festival

From humble beginnings in the 1950s, an annual performing arts festival has grown to a huge size, with over 750,000 tickets sold from a number of outlets each year and more than one thousand acts appearing across some 150 different venues. Managing these numbers has become increasingly difficult. The festival has its own website, which is maintained by the core in-house staff (ten full- and part-time workers), and although email is used reasonably frequently, the telephone remains the most popular method of communication accounting for a significant amount of staff time.

A bespoke eCRM solution is designed and implemented, which immediately allows the festival's administration staff to deal with agents, performers and other contacts on a more personalised level. Rollout begins immediately after the festival closes, thus minimising the disruption caused to staff, patrons and partner organisations alike. Thanks to the contact log that the CRM system automatically creates and updates, the risk of lost messages leading to missed opportunities is eliminated. The festival's own box office is able to liaise with other vendors in a more efficient manner, since a sophisticated ticket booking and distribution mechanism is an integral component of the system. A web-based enquiry system allows the public to check for seat availability and book tickets online, cutting the need for temporary customer enquiry staff. Existing databases are standardised and linked to the new system, creating a broad, new and extensible resource, and highlighting potential for similar shows and multiple sales.

Agencies offering accommodation for performers and patrons may wish to advertise on the festival's website, thus increasing revenue. Since the festival is partly backed by an Arts Council grant, reports and figures covering visitor numbers and expenditure can be generated and disseminated automatically, adding increased and measurable value to the new system.

Scenario VI – Natural Heritage Centre

A natural heritage centre requires a new technical alternative to its current, paper-based visitor tracking system. The centre currently utilises nothing more technically advanced than a telephone and fax machine. Staff and volunteers split their time between practical and administrative duties, depending on who is available at any given time. As visitor numbers increase, the centre realises that the system is inadequate in many ways, not least in time and resource management.

With the introduction of a PC and simple website, coupled with a relatively inexpensive off-the-shelf CRM package, the centre staff are soon able to automate email answers to FAQ's (such as opening hours, the types of animals that may be seen at a particular time of year). This increases visitor numbers and frees staff and volunteers from those repetitive and mundane enquiries allowing them to concentrate on the real business of the centre. Although Internet usage continues to grow there are many potential visitors who may not have access to the Internet, and provision for telephone enquiries to be dealt with as efficiently and courteously as email will continue to be necessary. The bulk of the costs is anticipated to be in updating web content and in the time required to train staff and volunteers.

Benefits and Risks

Summary

One of the most main reasons for implementing a CRM strategy is that the information held by an organisation can be understood and manipulated in new and more efficient ways. With a clear understanding and profile of existing and target customers, an organisation can use CRM software to make better use of its contacts and make visible

pathways to new business, perhaps even from existing sources that have previously gone unrecognised. Contacts can be maintained in the database, forming a searchable and germane resource. A greater sense of unity within an organisation should emerge as a result of this process of information networking.

Clear client orientation is appealing to a customer's sense of worth and value, and it can result in better client communications, *more* efficient interactions between staff and other professionals, and innovative proposals for new business. A CRM strategy provides the template for achieving these goals in the short term and the mechanisms for building a long-term company asset. The downside is that organisations occasionally look only inward when implementing a CRM strategy. Should this occur, a certain amount of personalised client perspective may be lost initially and the outcome could be an insulated vision of the customer base.

The considerable challenges of implementing CRM, in terms of both technology instalment and employee acceptance can, potentially, contribute to this restricted scope. Some internal adjustments will inevitably have to be made to the organisation. These adjustments are not being made for the benefit of the organisation alone, but with the aim of achieving better customer relations: the CRM venture has benefits for both company and customer as its overall aim. With this in mind, an organisation can make the required adjustments with a global goal in mind rather than making such decisions individually and, perhaps, in a vacuum.

The most common challenges faced by organisations implementing CRM are perhaps those concerning the technology. Technical integration is vital to successful instalment, and requires disparate components to be made compatible within the infrastructure. An organisation risks the loss of crucial information, as well as time and money unless it pays proper attention to this integration. Similarly, the complex technologies that support the infrastructure of a CRM system can require considerable time and skill to understand before the benefits of implementation may be seen. The distributed nature of the CRM software environment necessitates a constant upgrading and maintenance cycle in order to remain effective. Application changes therefore present a challenge when being distributed to a large user community, and can impinge on the short-term return on CRM investment.

Since off-the-shelf CRM systems tend to be aimed at smaller businesses, there is often a common misconception that the configured solution will be immediately effective. Some of these systems will meet the needs of an organisation, but rarely before considerable structural adjustments have been made. Bespoke systems aimed at larger corporations will be tailored to make the adoption of the system a relatively smooth process but in all cases CRM implementation is an intensive process and must be carefully considered before major decisions are taken at each and every stage of the rollout.

With a CRM system successfully integrated, an organisation will be able to rely on a responsive and accessible service for employees and clients. Data can be disseminated between departments, enabling all users to acquire a fully rounded view of customer information. A significant amount of time must be invested in demonstrating the benefits of the new system to employees. If internal acceptance is initially weak (and worse, if it remains so), the system will ultimately fail at one of its primary functions.

Tabular Overview

Benefits	Risks
Clearer understanding of customer / patron / user identities and interests.	Attempting to define target areas whilst simultaneously implementing the new strategy may result in an insular vision.
New customers may be attracted by a unified vision within the organisation.	Danger of developing CRM in a vacuum, as a result of considerable internal adjustments.
Information held by a CRM system can be understood and used in new ways.	Loss of data and internal resources due to lack of attention paid to technology integration.
Better communications, both internal andwith customers / other related organisations.	Time, skill and capital will be required to install complex systems.
A flexible system, beneficial to employees, customers and partner organisations alike.	Ongoing upgrade and maintenance may be required, possibly resulting in costly downtime.
A system can be tailored to meet the needs of an organisation either before or during implementation. Invaluable when done correctly.	'Off-the-shelf' systems will require more attention to integration than perhaps initially anticipated.

Introducing the Technology

The initial processes of implementing a CRM solution are contingent on several factors, not least of which will be the organisation's current depth of technological involvement. On one hand, a new organisation starting from the ground up will be able to plan its CRM strategy from day one. The **Tate Modern** (London) is a good example, having begun with a 'clean' information set rather than inheriting a collection of data of unknown accuracy and completeness. Prior experience can contribute to arriving at an effective design. An established organisation may have a large number of experienced staff, but the likelihood is that many different working practices will have been followed in the past, and standardising these can be onerous, conflict-ridden, and more time-consuming that creating the data from scratch.

Given the focus of CRM technology on a unified approach, its introduction will depend on positive employee relations. Staff may be set in their ways with regard to working practice. Glaring inefficiencies may initially be viewed as 'just part of the job' and any attempt to iron them out viewed variously as an attempt to reduce staff autonomy or as unnecessary managerial bureaucracy. Demonstrations of new software and its capabilities should be held prior to implementation, in order to allow employees time for adjustment. The users must be able to identify a definite improvement to their working lives if the system is to be a success. Teething problems with the installation of new systems makes it prudent to run with both systems during the initial stages of rollout, and to phase system changes in on a gradual and modular basis.

Database construction is likely to be the single most problematic part of the CRM introduction process. Given the current level of sophistication of database management systems it is likely that many employees will use a database without having much of an

understanding of the processes at work within it, or of the pressing need for uniformity and consistency in data that are entered into it. They are even less likely to be aware of the complex processes that went into the analysis of the information that the database manages nor of the effort that went into design of the database application itself. Sets of acceptable values should ideally be included in the database design to prevent data from being compromised. This is a problem that CRM purchasers must address if the system is to be worthwhile. A new server may be required to host a large, centralised database, and if an organisation's computers were not previously networked; this will have to be done. These requirements will inevitably add to the cost of the CRM system, making essential a step-by-step approach in the significant outlay involved.

A total eCRM solution is rarely cheap, and the costs are difficult to forecast without an analysis of an organisation's existing software, hardware and working practices, but if rigorously thought-out the system should pay for itself in the medium-to-long-term. It may be tempting to choose a CRM system that is more feature-heavy (and therefore more expensive) than is strictly necessary. Many organisations suffer from a negative return on investment for some time after putting a brand-new eCRM system into place. The benefits of certain marginal features must be weighed against the costs involved in order to justify the inclusion of each component. Needless to say, the correct time to carry out this process is at the planning stage, not during rollout or following the system's introduction. Correcting errors can be as much as ten times more costly after implementation than at the development stage.

CRM vendors often claim that software rollout can be accomplished 'quickly, efficiently and cost-effectively', but measuring these factors objectively is difficult, and attempting to gauge them empirically can become a frustrating and occasionally fruitless task. In making the decision on which CRM system is most suitable, a key point for consideration will usually be cost. Investing in a custom-made system may be inappropriate or unfeasible for one organisation, but crucial for another. If corners are cut at the initial stages of research and planning, greater costs are likely to be incurred later in the process. Ready-to-use systems generally offer all of the standard features of a fully developed CRM system, but will require more thought and effort if the implementation is to meet the specific needs of an organisation successfully.

Indeed, it may transpire that the system is not capable of meeting all of these needs. The system can still be adapted to a degree sufficient to make it workable, but the likelihood is that it will remain less efficient than a bespoke system. In this market, as in many others, you get what you pay for.

Complacency is another danger that can befall larger companies who seek to install customised systems. To assume that all necessary work has been completed by the CRM provider is to neglect the internal adjustments that may still remain to be made. The software may be compatible, and the system's capabilities may meet or exceed the particular needs of the organisation, but a significant amount of time and effort must still be invested to integrate the CRM package usefully with the organisation's existing systems and user community.

Customer feedback should be sought at each stage of implementation. This acts as a reality check for developers who often get carried away with the technology, and prevents them losing track of their original goal.

Appendices

Appendix I – Technology suppliers & developers

Suppliers of large, bespoke, total CRM solutions include **Siebel**, **PeopleSoft**, **Amdocs** and **Oracle**. Siebel is currently the market leader in CRM software by a substantial margin. Founded in 1993, the primary focus of the company has been to provide full-scale solutions to large businesses. It has recently begun to incorporate small and medium-sized businesses into its remit, and provides a number of eBusiness products for sales, marketing, and partner and employee relationship management.

Peoplesoft is another major player in the CRM market. Its latest CRM suite is Version 8, an Internet-based solution using XML and a standard Internet browser. **PeopleSoft's** *Pure Internet Architecture* operates without additional client-side software. It has begun to focus on the small to medium enterprises (SME) market, and now offers a variety of additional modules aimed at tailoring its software to a specific sector, such as finance, government, or education.

Oracle, the leading database platform since the 1970s, offers a complete e-business suite that interacts with its widely-known DBMS. **Oracle** is making steady progress in the CRM market, and is one to watch given the huge amount of database experience on which it can draw when building CRM solutions.

Among other providers that target small-to-medium sized enterprises are **OnContact**, **Sareen**, **FrontRange** and **ACT!**. **OnContact's** CRM package is called *Client Management Software* (CMS), and is aimed squarely at the middle-market. CMS can be run in both *Windows* and Web environment, simultaneously, allowing customer-facing staff increased flexibility.

Sareen's *OfficeTalk* package combines the four primary business areas (Customer and Contact Management, Time Management, Deliverables Management and Communications Management), is based on a robust **Sybase** *SQL Anywhere* DBMS, and claims to be ideal for the SME with two or more staff. While CRM solutions tend to be geared towards the larger end of the business scale, it has been said that even a company with only one customer and one competitor needs to employ some kind of CRM strategy if it is to maintain/improve on its position. This strategy need not employ dedicated technology, but the issue must be addressed.

ACT! 6.0 is another system ready to run out-of-the-box. It offers a package that links information together to provide individual contact records. It claims that new users will be productive immediately, and makes use of 70 pre-defined fields to manage contact information. Its features include built-in templates for letters, emails, memos and faxes as well as the option to create custom fields for more specific information. The system can share information with *Outlook* and can be synchronised with any *Palm Powered* device.

A comparable product to *ACT!*, **FrontRange Solutions** offers the *GoldMine* CRM system, which now features a variety of individual modules designed for such tasks as contact management, sales and marketing, and customer service and support. Self-service is made possible by allowing customers to access their details via the Web, providing the additional benefit of reducing the time needed for staff to answer simple queries.

Digital Asset Management Systems

Executive Summary

There has never been a more pressing need for organisations to control and manage their digital assets in an efficient manner. As resources are increasingly 'born-digital', and moreover stored in digital form alone, the management and monitoring of these valuable assets throughout their entire lifetime has become essential. Digital assets typically cycle from creation to multiple and varied uses and changes, and later into archives from which they may be quickly and accurately recalled and re-purposed.

Many types of file may be considered as digital assets, from images, sound files and rich media/multimedia files to Web pages, progressive drafts of text files, and product brochures. A carefully considered plan must be implemented by an organisation if it is to succeed in maximising the usefulness and value of these resources. Even assets of little monetary value – for example, digitised company logos stored at different resolutions for different purposes, say for use on Web pages, in print, or on letterheads can be treated as assets, as they facilitate a stronger pan-organisational image When organised correctly, the positioning of these assets will minimise the precious employee time necessary to locate, select, use, update and store them.

Digital Asset Management (DAM) products provide the tools to 'ingest, index, categorize, secure, search, transform, assemble, and export' content in as many forms as an organisation requires.[9] This report details the fundamental technologies at play within a standard DAM system and highlights how these technologies may be put to work together in order to create a sound, reusable and re-purposeable set of resources.

Featured heritage case studies in this section include the British Library and the Victoria and Albert Museum. Additional scenarios serve to outline some of the current and future potential that Digital Asset Management software may hold for a wide variety of organisations with an interest or focus in cultural and other forms of heritage.

9 Artesia, www.artesia.com

An Introduction to Digital Asset Management

The problem

All manner of cultural institutions, from archives, libraries, and museums to natural and environmental heritage bodies, are seeking new ways to expand their services. The development of software and processes facilitating the dissemination of and access to digital content has enabled institutions to support services exploiting its use. Much recent digitisation work has been carried out as discrete institutional projects producing standalone Web pages or CD-ROM's. Few individual heritage institutions have the technology or experience needed to treat these digital products as renewable and manageable resources, and current procedures and systems do not provide efficient ways of managing or providing access to them.

Digital assets have the unique characteristic of being both product and asset. Some digital assets such as documents, images and Web pages are created and exist in digital form alone, while others like text, still images, video, and audio may be created through the digitisation of analogue material. Content has a value to institutions comparable to other assets such as facilities, products, and the less-measurable factor, expertise. Just as organisations have traditionally sought to maximise their use of financial, human, and natural resources, they will now aim to use digital assets to their full potential without having a negative effect on their 'value'. Value, of course, is not always obviously financial.

Modern Digital Asset Management Systems (DAMS)[10] provide mechanisms to manage digital resources. When associated or integrated with suitable policies, procedures, and licensing arrangements, DAMS provide a means of facilitating use of digital assets without impacting on the intrinsic value of the assets themselves. Digital Asset Management is the practice of using software applications and hardware (servers) to index, catalogue and store marketing tools and media assets in a centrally located, digital format. A DAM repository can be searched, shared, distributed and re-purposed to create a growing digital workflow environment, saving time and money, and achieving increased efficiency in communications.

Fundamentals of DAM technology

DAMS employ technologies such as commercially available database management tools to handle and manage resources, allowing users to discover them with ease and speed and owners/creators able to monitor their usage and version histories. A DAM storage system may take the form of a number of media catalogues with pointers to where the assets are stored (the traditional file structure), or asset repositories which hold the media information in a database, or both. Privileges can be set to allow only in-house staff to modify the material, and give access to all online or, by means of a password system, to a select user group. Digital Asset Management provides a digital archive which stores valuable resources in a pan-organisational infrastructure that helps prevent obsoles-

10 Sometimes known as Media Asset Management (MAM) or Digital Media Management (DMM) (Source: Bill Trippe, 'It's a Digital World, After All: Options in Digital Asset Management', EContent magazine (October 2001), available online at http://www.econtentmag.com/r7/2001/trippe10_01.html)

cence or duplication of effort, and offers searching and browsing tools to authorised users to locate and retrieve the assets managed.

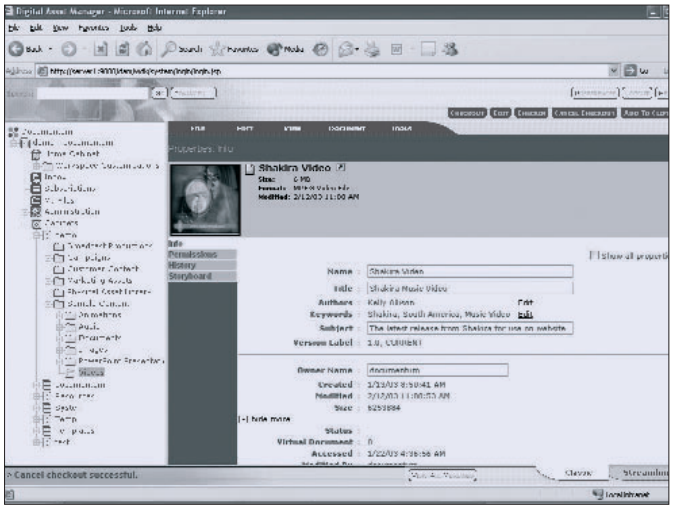
A DAM solution is likely to comprise of the following three broad components:

1.Archive

The archive is central to the DAM venture. It allows assets to be stored, manipulated, re-used and re-purposed for future work, thus saving time and effort, and has the obvious benefit of cost reduction.

2. Project Management tools

Specialised tools can facilitate collaboration between departments of an organisation, or lead to smoother communications between the organisation and its external project partners or customers. They will assist in further reducing costs associated with running collaborative projects, such as postage and packaging, and other traditional forms of communication.



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3. Rights Management

User permissions can be followed and intellectual property rights tracked automatically using Web crawlers/ spiders, image watermarking and object steganography, which involves placing an invisible, non-removable tracking mark within the digital asset or its associated, indivisible metadata.

End-to-end solution vendors, such as **Artesia**, with its *TEAMS* product, speak of the need for a DAM product that has the power to 'ingest, index, categorize, secure, search, transform, assemble, and export' content in as many forms as required. Each of these functions may be of particular interest and relevance to the cultural heritage community, as this report will outline.

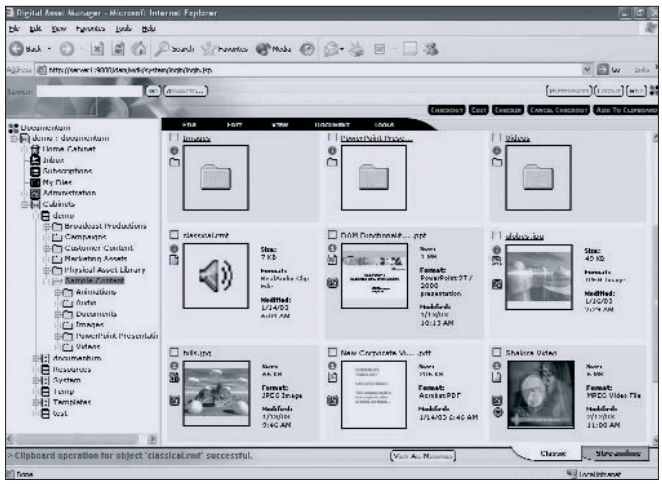
Metadata: theory

A DAMS can provide tools for managing digital objects from creation, through publication and dispersal, and eventually on to the archive. Systems can automatically accept the data output by the digitising process or accept input from other compatible systems. They can assign storage positions and set and monitor management access, security, and management attributes based on metadata assigned either by the object's creator or automatically during the digitisation and ingest processes. It can store a digital entity or a digital entity's *location* together with its metadata in a database.[11]

11 Holding large digital objects (such as multimedia files) in a database is not yet as efficient as storing them in a standard file system, so the filepaths of resources are often used to link the locations of such objects with their corresponding metadata, and to identify the whereabouts of the object itself.

Metadata is 'data about data' that improves access to resources and the information they contain. It can be divided into three main types: *descriptive* metadata, which carries information about the content of a resource; *structural* metadata, which is concerned with the context of one particular resource, and its potential relationship(s) with other resources(s) (for example, a 1930s cigarette card may be '#4 in a series of 8'); and *administrative* metadata, which deals with other issues such as rights and version-management. Metadata should be maintainable, consistent and usable.

A number of comprehensive schemes exist for managing such metadata. Many of them are suitable for storing metadata about digitally created objects. These include Dublin Core, *MARC* (the MAchine Readable Catalogue), *EAD* (Encoded Archival Description) and *ISAD(G)* (the International Standards Archival Description – 2nd edition). Interoperability is the goal towards which most metadata initiatives are currently moving, and Dublin Core has its own dedicated forum on interoperability[12] indicating the gravity with which this issue is currently being treated. One of the aims of Dublin Core is efficient cross-domain discovery and platform-independence, coupled with suitability for interoperable searches via linked searching mechanisms such as *Z39.50*. While potential interoperability is not currently a major factor in selecting a DAMS specification, the facility for cross-platform searching is likely to become increasingly valuable in the future.



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Where is DAM technology currently used?

Digital Asset Management systems can be found today in many of the world's largest and most influential organisations, ranging from the **American National Football League** (NFL) to **The Vatican**. They are also used in academic institutions in countries such as England (the **Courtauld Institute of Art**[13]), the Netherlands (National Archives) and the United States of America (Texas, Cornell and Stanford universities). At the **Cable News Network** (CNN), a central repository for the consolidation of production resources has been developed. CNN maintains an ever-expanding library with a vast catalogue of news archive material necessary for supporting television production processes in the news industry. Management of this material is automated to a significant degree, with different approaches necessary for different user roles and responsibilities.
The dispersal of content via different channels, for example standard television, interactive television, and the Web can in this way be enabled.

12 The DCMI Metadata Schema Interoperability Working Group (http://dublincore.org/groups/schema/)
13 See DigiCULT Thematic Issue 2, pp 33-37 for a case study on this college.

Due to their perceived and often very real costs, DAMS are as yet found infrequently in smaller cultural heritage organisations, but this is beginning to change. The **Tate Gallery** (London) is in the process of creating an asset database for its entire collection of more than 50,000 art works incorporating its existing *InSight* production process and image management system. This asset base will be made available to the general public at no charge and has inbuilt potential for future developments towards commercial exploitation and 'seamless' Web publishing.

How Digital Asset Management Works

Introduction

DAM software is based around a central database or collection of linked databases, as is Customer Relationship Management software[14]. Management and long-term preservation of the large volume of material likely to be held in a DAMS depend upon a storage management system capable of moving media entities between locations. An organisation's ability to harvest, reuse, and realise the value of its assets will only ever be as good as its mechanisms for storing and retrieving assets. DAMS can generally handle a number of different media types, such as creator-structured and XML documents, images, audio and virtual reality objects, and there are a number of systems which concentrate on media types for specific business areas. The broadcast media is a prominent example.

Version management, derivatives, archiving

An essential digital asset is likely to exist in a variety of different formats and versions. Keeping track of the use and change histories of the original, 'parent' asset and its derivatives or 'children' can be of paramount importance to an organisation's efficiency and profitability.

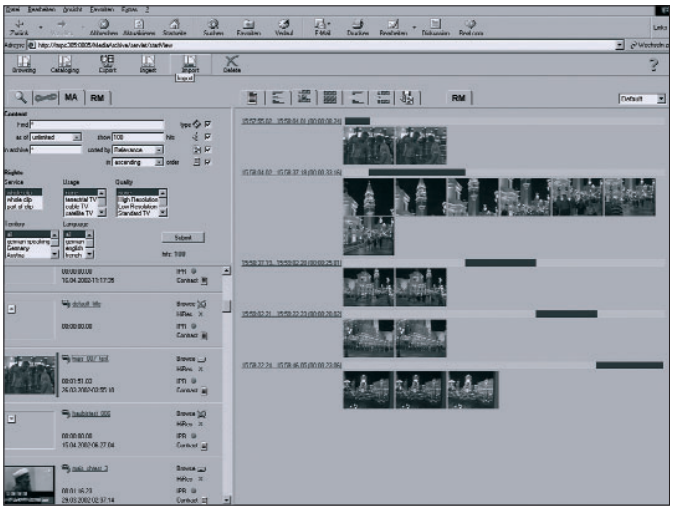
Version management can be applied by authors or developers, including application code, graphics, text and other file-based content. If several authors are involved in developing content together, the version control system 'locks (makes 'read-only') a file during editing or between editing and reviewing, to ensure that no two authors modify the same document at the same time'. A development of this enables multiple authors to edit content simultaneously, followed by a managed merge process. This is comparable to recent developments in Database Management System (DBMS) functionality, whereby the DBMS regularly saves 'rollback' points which can be recalled if simultaneous transactions conflict or a system failure occurs.

The **BBC**[15] is currently undertaking a major asset management project, designed to optimise and align its current born-digital assets and its existing archives. Such a system

14 See section on Customer Relationship Management.
15 http://www.bbc.co.uk

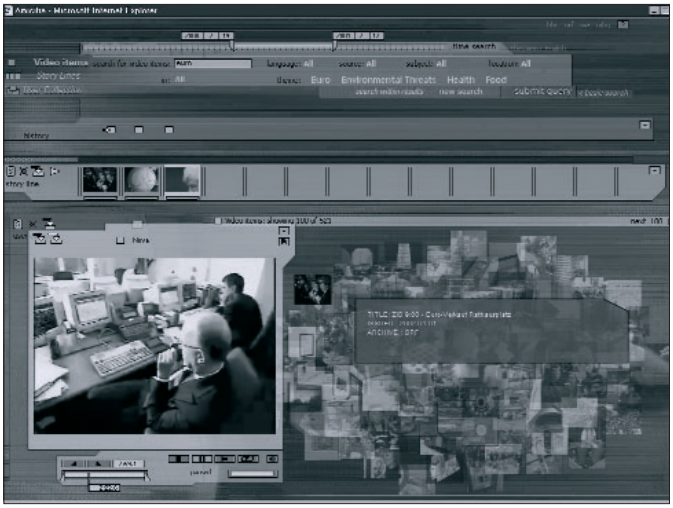
has to handle a variety of media types and distribute them through different channels: radio, television, print, and online. The project covers both newly created assets and archival material, and the overall strategy incorporates the needs of different types of content creator. Capturing metadata throughout the lifecycle, from the initial idea through creation and storage, will allow the system to fulfil its potential.

Sweden's **Sveriges Television** network[16] has recently put into place a DAM system which includes the automatic storage of content in a central repository and the generation of metadata from television footage. Significantly, all of the network's media assets are stored, handled, and transferred in a standard format, .dif, allowing a dedicated DAM system to be built specifically for content held in this way. This work is comparable with work supported under the Fifth Framework's IST Programme on the *Amicitia* project,[17] which 'aims at building the base for a continued and viable digital preservation of and access to television and video content through the construction of various vital components enabling a digital archiving system to serve all required roles in ingest, management, access and distribution of audiovisual material'.



© Amicitia

The professional interface of the Amicitia project



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The public Web interface of the Amicitia project

Metadata: practice

A carefully considered metadata strategy is fundamental to successful DAM system implementation. Indeed, the stored metadata is the foundation upon which requests for material and the subsequently found objects sit. A number of varied metadata standards have been employed throughout the cultural heritage sector, mainly in library and archive environments. These standards have been improved and expanded recently to cover new and innovative applications and uses of digital content. The UK Government

16 http://www.svt.se/
17 http://www.amicitia-project.de/

has recently made recommendations for metadata in the public sector, using the Dublin Core, and this endorsement is expected to accelerate developments.[18]

In order to maximise their output, DAM systems should provide support for integrated indexing and search functionalities. An indexing application navigates its way through a file repository, 'reads' the text files held there, and constructs a separate database of predefined content elements and metadata. Metadata contained within the media asset allow users to narrow their search strategies, and gives users a better chance of finding exactly what they are looking for.

Content classification systems enable administrators to organise user-specific metadata values as an aid to specialised Web functions such as site analysis, personalisation, and content targeting. The ability to personalise the user's experience is dependent on linking dynamic page content to previous user actions. User personalisation will also require the introduction and maintenance of a membership database, in order to store customer attributes and other relevant information.

Databases

Matching a future DAM solution to existing database systems is of the utmost importance. It is also crucial to differentiate between the different types of database likely to be in use across an organisation. For example, if the majority of staff are currently working on standalone databases such as *Microsoft Access*, the information from these will have to be standardised and streamlined in order to facilitate distribution across a network. This is the only way that DAM software can fulfil its function efficiently. An upgrade to a more powerful client-server database will also be necessary if the assets are to be made available for public Web access.

Object databases have been and are being developed which hold the assets themselves in a DBMS as user-defined objects. Storage of assets in a database will increase the granularity (or the level of detail at which the code or data is considered) of an organisation's assets to a significantly greater degree than the standard file approach. Storing assets in a file system with pointers to the location of the metadata can be more efficient, up to a point, especially when the content is linked with a freely-accessible Website. The decision on which strategy to adopt must depend on the size, formats and idiosyncrasies of the collections to be managed, as well as the organisation's ability to create and maintain an expensive single-purpose resource.

Proprietary and hosted DAMS

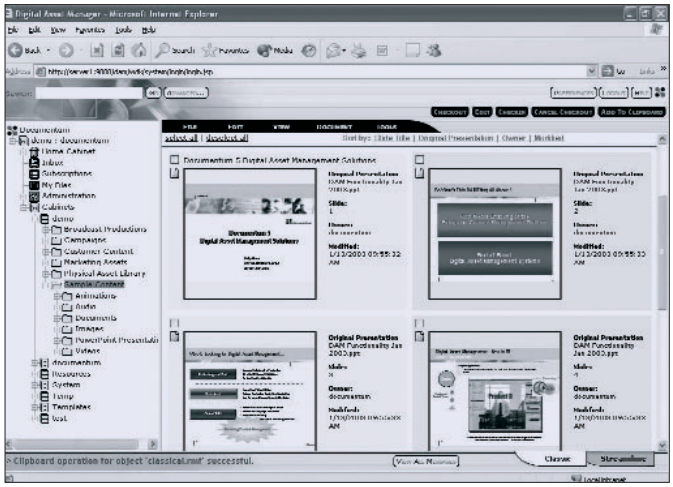
An organisation's Digital Asset Management systems are commonly hosted in one of two ways: locally (i.e. on-site) or hosted (i.e. online). Each has its own benefits and shortcomings. Server-centric, ASP-based solutions may be popular among smaller organisations that have fewer assets to store, or whose asset formats are relatively uncomplicated. A managed, Web-based solution allows an organisation to combine the security and

18 See http://www.govtalk.gov.uk/documents/e-GIF_version_2.doc for the British Government's explanatory document.

accessibility benefits of standard software packages with the potentially limitless opportunities offered by the Web. Hosted Web-based solutions can be customised to meet an organisation's particular needs and once in place, the Website will be maintained and managed by the host company. Hosted solutions may provide an ideal balance of efficiency, capability and affordability for smaller institutions, without the need to maintain the software, hardware or expertise on-site.

Although this is rare, a notable risk is that the host company or its Web site may collapse, potentially taking irreplaceable data down with it. Contingency plans must be put in place for such an eventuality.

The option to upgrade to a more technologically involved package must also be present should the company wish to begin operating beyond its current sphere. Essentially, the risks of each approach must be carefully weighed against the potential financial rewards.



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The Documentum interface

Potential difficulties

The first question in deciding on a DAMS strategy is whether to customise an off-the-shelf solution or to build or commission a bespoke system. The question will be settled depending on the size of the organisation and the scale of the asset repository that needs to be managed. Building a bespoke system will involve carrying the overheads and risks of recruiting and retaining specialised staff, and for many smaller organisations this may not even be an option. Ordering a bespoke system from a much smaller vendor may be less expensive, but it also carries the risk of the vendor collapsing along with the customer's funds. In any case, selecting the right product and vendor will take a significant amount of consideration. It will also involve setting budget target levels, assessing the suitability of the technologies for the assets and the existing organisational working practices and then attempting to balance these crucial factors.

The accuracy and consistency of metadata will also be crucial. Prior to rollout, individual users who deal with a large number of files may hold their own guide or index to, perhaps, different versions of the files held on their own computers. This approach must be firmly discouraged. Among the major difficulties that planners face is to get employees and customers to use the workflow and asset management as part of their everyday business. It is essential to have support across the user base.

Database integration may also be particularly problematic and may require outside expertise.

Future developments in DAM technology

As is the case with many other technologies, the future of Digital Asset Management is heavily geared towards extensibility and XML compliance. New and developing products have the advantage of increasingly granular control, and facilitate the easy reuse of content. The primary advantage of XML-based systems is that they allow the separation of form and content, with the mark-up acting as a user-defined vessel for the content itself. **Adobe's** *XMP* (Extensible Metadata Platform) software allows metadata to be held in the header sections of individual files, permitting simultaneous transfer of content and custom-mapped metadata between discrete systems. In the manufacturer's words, *XMP* 'provides *Adobe* applications and workflow partners with a common XML framework that standardizes the creation, processing, and interchange of document metadata across publishing workflows.'[19] The inclusion of metadata within the file structure allows the assets to retain their context even when accessed within a different application. *XMP* is based on the **W3C's** open standard for metadata, the *Resource Description Framework* (RDF)[20], and is shared as an open-source license. Users and integrators are allowed free access to the source code via the Software Development Kit.

Further developments in DAM are expected as a result of the new *WebDAV* standard, which allows collaborative authoring and editing of content via remote Web servers. The growth in object and object-relational databases will also have a marked effect on the DAM world, as database companies become more familiar with helping to define particular, sometimes company-specific and proprietary asset types.

DAM Technology and the Heritage Sector

Brief background

Digital Asset Management and the cultural heritage sector are just beginning to develop a working relationship, although DAM technology is currently in place in a broad range of culture-focused organisations, from archives such as the National Archives of the Netherlands to universities (Texas, Cornell, Stanford, and the Courtauld Institute of Art) and the Vatican.

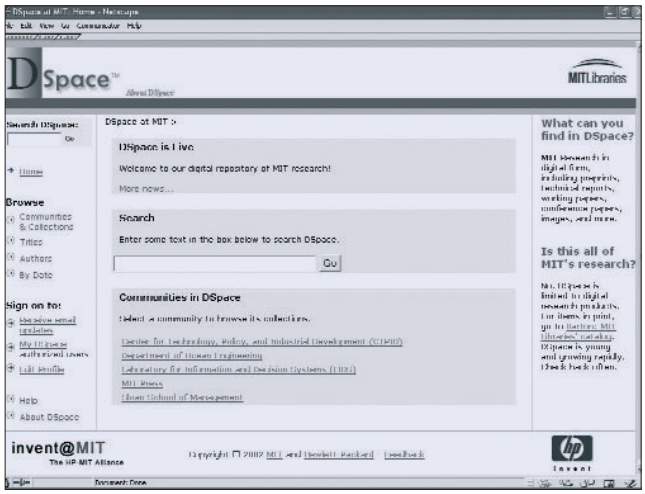
The reason why DAM is not currently found in more cultural organisations is partly due to its newness as a concept, and partly to its relatively high expense and focus on return on investment (ROI). ROI is a factor with which heritage organisations have been traditionally less interested, given their special funding status, but are becoming more so all the time. DAM vendors often specifically target sectors such as publishing, e-business and broadcasting. It is forecast that as the costs of small-scale, off-the-shelf DAMS drop, and open-source DAM solutions such as **MIT's** *DSpace*[21] become more popular and wide-

19 http://www.adobe.com/products/xmp/main.html
20 http://www.w3.org/RDF/
21 http://www.dspace.org

spread, the relationship between DAM vendors and cultural heritage organisations should become ever stronger.

Digital Asset Management will adapt and change in accordance with future developments in working practice and asset storage schemes, and DAM will become less of a buzzword and more of a fundamental need for many types of business.

There now follow some case studies which demonstrate the ways in which DAM planning has been carried out in the cultural heritage sector, and a set of scenarios which outline the potential for DAM in a variety of types and sizes of organisation.



© DSpace

The DSpace user interface

Case Studies

Case Study I – The British Library[22]

The **British Library** (BL), the national library of the United Kingdom, is recognised as one of the world's great libraries. Its vision is 'To help people advance knowledge to enrich lives.' The Library's collections include about 150 million items and three million items are added annually. The BL operates the world's largest document delivery service, which supplies around four million items a year to customers around the world.

The Library currently has a backlog of voluntarily deposited items, ranging from CD-ROMs to e-books and e-journals. Recognising the need to address this backlog, senior management have been following the development and uses of Digital Asset Management systems in comparable organisations. Work at the Public Records Office, the Koninklijke Bibliotheek (Dutch National Library), the BBC and the Library of Congress has been watched closely. As the keeper of the British published national archive, the BL has a special responsibility for preservation, and this has helped define its asset-management needs.

The decision to use DAM (or, more accurately, Digital Object Management) technology emerged as a result of a number of pilot projects carried out during the 1990s, as well as from experience gained from the Digital Library System project which was carried out in 2001-2 in collaboration with **IBM**. The Library's director of e-Strategy, Richard Boulderstone, is taking the lead in developing this strategy. The Library has acquired a new Integrated Library System, which will support the functions of acquisition, cataloguing, and Online Public Access Catalogue (OPAC). The system is expected to be in place in early 2004.

The DOM Programme will build a system capable of handling digital entities, including images and textual items, in a variety of formats and together with their metadata in

22 The following material is based on a telephone interview with Richard Masters, Technical Architect in the e-Architecture Team at the British Library, and also on information from the Library's website. The interview was conducted on 13/01/2003.

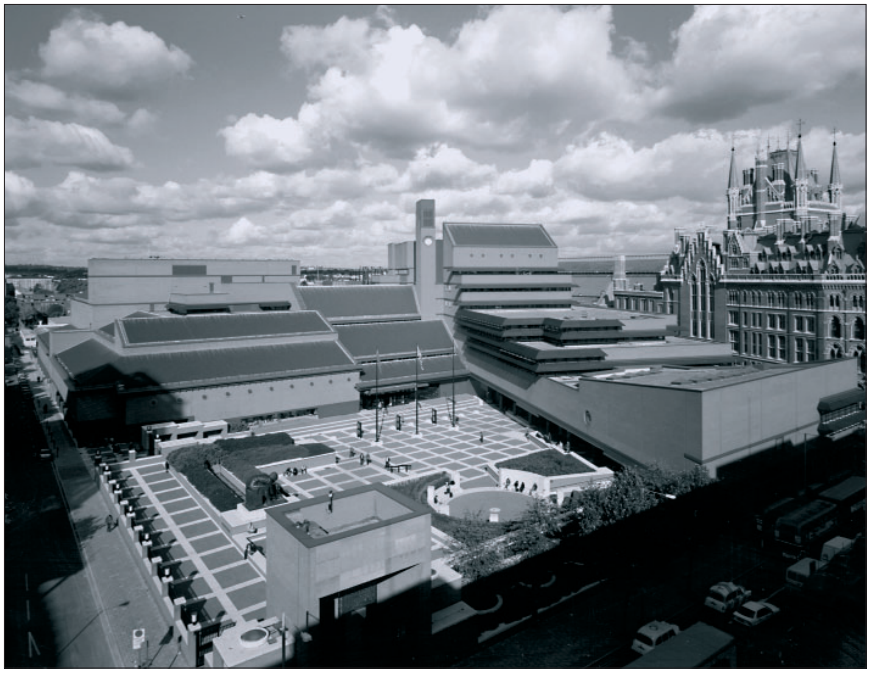
a secure, managed environment. The system should be in place in time to handle the influx of voluntary and legal deposits, due to arrive in early 2004. Much of this material will be 'born-digital', but some will be the result of digitisation programmes.

The Library's DOM strategy is currently still in its design phase, and developers are considering three main options: adapting an open-source product (such as *DSpace*), using a commercial product, or commissioning their own bespoke solution. In the past the Library has favoured in-house developments, but policy has changed recently. Where suitable commercial off-the-shelf packages are available the library will use these, mainly to reduce redundancy of effort and costs, to enable it to benefit from the community of product users, and to take advantage of system development and maintenance programmes.

As a public sector organisation, all substantial purchases must be put out to tender, and in this case the process is expected to commence later in 2003. The advantages of open-source products are widely recognised – large and enthusiastic user groups, significant cost savings, conformity to standards. Some open-source applications lack adequate documentation which can impact seriously on ease of use and maintenance. Configuring an off-the-shelf system can be time-consuming and costly, as we saw in the case with CRM software (see above).

It is anticipated that most of the integration and rollout process will be carried out by the Library's experienced in-house staff. While some elements may require the help of consultants, the Library aims to keep this to a minimum. The Library has a number of other ongoing projects dealing with digital items, and these will eventually be integrated with the DOM Programme. In terms of workflow management, the introduction of the system will be carried out incrementally, beginning with new materials and followed by the gradual integration of the backlog into the new environment.

Intellectual Property Rights monitoring is likely to be integrated into the DOM system's functionality. Management of IPR becomes increasingly central to the Library as it



The British Library's new building at St Pancras, London

moves to raise substantial income from the sale of images, documents and journal articles in electronic form.

It is hoped that the significant pieces of the programme will be in place by late 2004 or early 2005, although as with any large-scale system implementation activity the British Library will evaluate progress and the quality of deliverables throughout.

Case Study II – The Victoria and Albert Museum[23]

The **Victoria and Albert Museum** is the UK's national museum of applied and decorative arts, and is considered to be a world leader in this field. With over 750Gb of digital assets, ranging from 600Gb of digital 2D images to *QuickTime* movies, CD's and Websites, and with a further two million analogue images awaiting digitisation, the Museum is now looking to manage its digital revisions and maximise the potential of its treasures via a dedicated Digital Asset Management system.

© The Victoria and Albert Museum

Digitisation at the V&A

The Museum's collection of digital content is growing steadily, and staff have found that the tools used for managing the assets, a combination of *UNIX* command line scripts and standard *Windows* applications which need manual intervention, are no longer able to meet their needs.

Recognition of the need for a DAMS came from the Photographic Studio, which has been responsible for managing the image archive since 1856, and has great expertise in analogue image management. With the advent of digital images, it quickly became apparent that new tools were needed to meet new targets for the exposure of collections in a virtual way. The increased demand for re-use of assets has quickly shown a need for automation. All content re-uses are currently routed through one museum section with the complex loading routines becoming a bottle neck in what should be a simple service task.

While no comparable cultural institution in the UK has yet fully implemented a DAM system, all of the national museums now have Department of Culture Media and Sport (DCMS) agreed targets for the amount of their collections represented on their Websites. Image-makers in the UK at conferences of the Association for Historical and Fine Art Photography[24] (AHFAP) have discussed the topic at length. To museum Photographic Manager James Stevenson it seems that most image-makers in the UK allow their IT people to take the lead in decision-making in this area. At the V&A, while the IT department will need to be technically involved, user requirements will lead in the decision-making process.

© The Victoria and Albert Museum

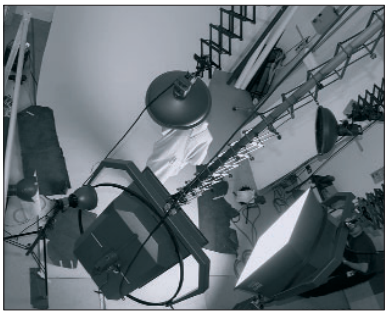
Digitisation at the V&A

23 The following material is based on an email questionnaire completed in January 2003 by James Stevenson, Photographic Manager at the museum. Additional information comes from the museum's website (http://www.vam.ac.uk)

24 Association For Historical And Fine Art Photography, UL: http://www.ahfap.org.uk/

For Stevenson, the parallels between the needs of the commercial and the cultural sectors do not seem very close. Much commercial concern seems to be based on cataloguing and indexing, an area in which the cultural sector naturally has much expertise. The closest commercial organisations would be picture libraries, and these are likely to be in direct competition with the V&A.

A DAM system is considered to be crucial for the expansion plans of the museum's picture library. The picture library staff recognises that in order to be competitive the library will need to deliver images to clients as quickly as possible. A DAM system is seen as the most efficient way to do this and to ease preparation of new material for the picture library Website, another critical issue for effective marketing of images. It is forecast that the DAMS will be used extensively by the public relations and marketing departments, allowing them to expand the visibility of the museum, and enabling them to target their campaigns more accurately.



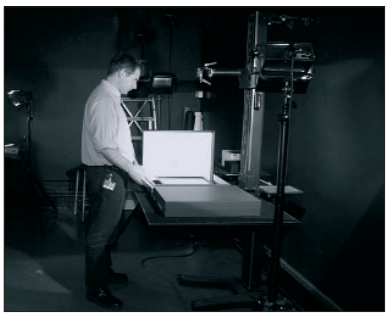
Digitisation at the V&A

It is anticipated that the V&A's eventual DAMS selection will consist of an off-the-shelf system, configured to meet the museum's particular needs. The current favourite is *MediaBin* from **Imation** which seems to have a method for the re-use of material allowing a large variety of formats to be re-processed from the master by scripts controlled by an administrator. Other systems under consideration are those supplied by **Picdar** and **Artesia**.

After implementation, which is expected in the next fiscal year, the proposed order of rollout will be as follows:

1. system administrators and asset producers;
2. primary users of assets, picture library, Web team, design studio, print unit;
3. key external picture library clients;
4. second stage users, PR, marketing, development office;
5. key external PR, marketing, development clients;
6. third stage users at the main museum site, curators, and other staff;
7. remote site users.

It is expected that the only external expertise required by the museum will be in specialist training for the commercial product. All other training and expertise will be in-house.



Digitisation at the V&A

The Documentum interface

Case Study III - BBC Worldwide (www.bbcworldwide.com/)[25]

Since the first publication of *Radio Times* in 1923, **BBC Worldwide** has been the commercially-funded service of the **British Broadcasting Corporation.** It covers a broad variety of businesses covering international programming distribution, TV channels, magazines, books, videos, spoken word, music, DVDs, licensed product, CD-ROM's, English language teaching, videos for education and training, interactive telephony, co-production, library footage sales, magazine subscription fulfilment, exhibitions, live events, film and media monitoring.[26]

Managing the variety of digital assets from these business arms is a huge task, and the company's former strategy of archiving resources on Compact Discs was becoming untenable. The processes of finding, altering and re-filing assets were significantly less efficient than desired. A new technological approach was necessary to streamline these processes and to continue to convert resources into assets.

The decision was taken to implement a DAMS to handle and automate these tasks. The product selection was carried out between IT Systems Manager Mark Ginns from **Worldwide's Publishing Systems** department, and his colleague, Digital Asset Manager, Jo Mercer. After evaluating a number of similar products, **Picdar's** *Media Mogul* was the eventual winner, with Ginns and Mercer's decision based on the company's track record in similar working environments. **Picdar** created a new database for three of the company's thirty-one magazines and, when the system went live, the content was immediately accessible. Each image and article has history, usage, creator and copyright information linked to specific pages in the printed magazine, thereby providing an easy-to-use and fully indexed solution for finding, billing and reusing of a magazines' assets.[27]

According to *Conspectus* magazine, Ginns was delighted with the delivery.[28] The system has since been expanded to cover all thirty-one of the company's titles, and staff have access to all assets via a dedicated intranet browser. Further expansion is planned to cover syndication of stock footage and licensing arrangements, and may work with existing syndication agreement with **CBS** with which the BBC holds the sole agent's licence.

The DAMS introduction process has required a team of three staff members to mark-up the content, and subsequently populate the content database. The system has been well received by users, a crucial step in ensuring the success of any new tool.

Scenarios

Scenario I – An Archive

A small, recently founded brewing archive is looking to market its services to an expanding niche market of hobbyists. As many of the archive's potential world-wide users are unlikely to be able to visit personally, a Digital Asset Management system is set up to control the archive's growing Web presence and simultaneously link to the existing *MySQL* database which stores details of documents held, and digitised images of many of them.

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25 This case study is based on material from the Internet and from printed sources. All sources are credited in footnotes or in the body of the text. The websites were visited on 04/02/2003.
26 List from homepage, http://www.bbcworldwide.com/
27 According to Picdar's website, http://www.picdar.co.uk/htdocs/customers/bbc.html
28 Conspectus magazine, September 2002, p. 21. (Available online to registered users at http://www.conspectus.com/2002/september/article14.asp)

Given the archive's newness, the integration of the metadata into the new system is unlikely to be overly problematic, and an open-source DAM system will offer a cheap and user-friendly solution to its needs when used in conjunction with the widely adopted *Dublin Core* metadata scheme.

Using a combination of automatically generated emails and the re-purposed digitised versions of the most popular documents, the archive owner can offer image and replica sales of unique items to Web visitors, helping to stabilise the financial situation of the venture.

Scenario II – A Museum

A large national museum wishes to overhaul its e-commerce division, in particular the ways it advertises and sells its online products.

Using a dedicated DAM system, instant and potentially personalised online catalogues can be created dynamically and instantly in order to suit more closely the needs of each customer. Among other benefits, this will reduce the costs involved in printing and mailing individual paper catalogues. The same images can be re-purposed across the museum's various departments and users will be able to access the same set of assets, reducing the storage waste caused by duplicate images being held independently on multiple local hard drives.

A different set of products can be shown to tempt potential customers, with these products being selected according to the user profiles stored in cookies, and potentially in a linked database within the DAM system.

Scenario III – An Art Gallery

A city art gallery's Website is looking to keep its content current and ensure that the features change from one visit to another. Staid and static Web content can be a chief reason for visitors failing to return to a site.

With a dedicated DAM system covering Web content and digitised images as well as sounds, logos, and multimedia content, the gallery's Web team can provide a fresh and intriguing front page every time, increasing the involvement of Web visitors in the gallery's day-to-day business and hopefully encouraging them to visit in person not just once but many times. Old Web pages can be archived and recalled for future use: who is to say that a feature on the gallery's different approaches to Web-publishing over the years will not appear on the site in years to come?

Summary

Introducing DAM technologies into the cultural heritage sector is a crucial step if the sector is to ensure it is creating renewable resources. Any digital asset is only of value to an institution if the institution can manage the asset throughout its entire lifecycle. Tracking use and managing rights will be of specific interest to cultural organisations, which are only now beginning to maximise the financial potential of digital versions of their priceless treasures. For this reason, discussions of DAMS put great emphasis on the support they can offer in the area of rights management in matters like assertion, protection, and management. Protection comes in various forms, from managing access to the digital repository, to tracking users, controlling what versions of material users can access, and ensuring that IPR metadata is linked to the entity when it is delivered to the user.

Of course, DAMS must be used in conjunction with licensing arrangements, entity and user authentication technologies, and digital asset tracking services. The problem facing heritage institutions in this regard is that once they provide access to a digital asset they are likely to experience difficulty in monitoring its use, and in ensuring that it is only used by the licensee and for the purposes licensed. Few heritage institutions have the individual financial or legal resources to pursue those who misuse access to their digital assets.

Benefits and Risks

Brief introduction

There appear to be many potential difficulties when implementing the current generation of DAMS for use in heritage sector institutions, including their frequently generic nature, perceived high costs of purchase and upkeep, the complexities of the technical infrastructure required to maintain an efficient system, and the difficulties of ensuring take-up by staff members. Organisations need to assess both their need for DAM technology and the impact that it could have on the ways they use their information assets. Digital asset management represents a significant investment, and the ROI factor will become increasingly pressing. Factors used to demonstrate a healthy ROI prior to introduction may include:

- assessing potential customer requirements;
- projected gains in staff productivity;
- future cost reductions;
- new revenue opportunities revealed;
- value enhancements of existing assets.

Given the fact that most DAMS are built atop commonly available database systems, there is little risk of future difficulty with portability of information or compatibility with new finding aids provided these new technologies are backwardly compatible with existing DBMS. Where the real risk lies is in balancing the cost of integrating DAM strategy with existing systems and components, and the financial, temporal and user-focused benefits of this new and improved approach. While market leading solutions can run to a six-figure sum, many more modest solutions are available.

The temptation to over-adjust the functionality of a standard, off-the-shelf system can be strong, and organisations should ensure that the introduction of their DAM solution is kept as simple and straightforward as possible in the early stages to ensure pan-organisational take-up of the system.

Tabular overview

Benefits	Risks
DAMS support centralisation of discovery and access.	Expense. The costs involved in implementing a dedicated system should not be underestimated.
Provide increased coherency and professional consistency across multiple projects.	Streamlining. Bringing exiting systems and system components together can be an arduous task that may benefit from the introduction of outside expertise.
Verify integrity and authenticity of digital objects.	Staff culture. Employees and users may be accustomed to holding their own versions of files. This attitude may be difficult to change.
Facilitate automated rights management, and support good information management practice.	
Efficiency. DAMS minimise duplication of effort and resources, and can lead to repurposing opportunities.	
May potentially aid asset monitoring and report production.	

Introducing the Technology

The process of introduction

Generally, DAMS are considered as capable of managing the entire process from acquisition (ingest) of a digital entity through its retrieval, delivery, and use to its long term archiving. Commercial off-the-shelf DAMS such as **Artesia's** *Teams*, **eMotion**, **Documentum**, **IBM's** *Content Manager* and **Oracle's** *Content Management System* support these functions although not all with the same degree of sophistication. For example, some DAMS are able to handle time-based media such as audio and moving image material, better than others. Off-the-shelf packages, although often expensive, are for many organisations lower risk than writing new software. Some packages benefit from having a broad user community and hence a freely available support network.

Some DAM applications are beyond the financial resources of all but the largest of the heritage institutions, but some of the functionalities which make up a DAM system can be emulated using inexpensive generic applications such as the *Office* group of programs. These approaches tend to be higher risk, and require an additional degree of ingenuity on the part of the system developers.

Advice for organisations

Organisations thinking about introducing a DAMS might wish to ask the following questions before embarking on the investment:

- What new opportunities will a DAM system enable the institution to create? How will the institution measure whether or not DAM has achieved the objectives?
- What functions of DAM systems are particularly well suited to the needs of the institution?
- How can the institution ensure staff buy-in to DAM technology?
- What will be the cost-benefit ratio?
- Which DAMS technologies best fit the institutions requirements? How will the selection process be documented?
- Has the institution established that the target DAM system can be optimised for the data types which the organisation handles, that it supports adequate user profiling, and that the metadata categories supported are adequate?
- What impact will the introduction of a DAM solution have on organisational thinking about and use of digital content?
- What might the implications be in collaborating with other institutions to share a DAMS?
- What obstacles might be encountered when attempting to introduce DAM technology? How can these be overcome?
- What metadata are required to support the institution's application of DAM technology? How will the metadata be acquired and implemented?
- DAMS are based on a combination of technologies and methods, including software applications and policies and procedures. Have those elements that are software-based, and those concerned with policies and procedures been identified?
- Have plans to develop, test, disseminate, and validate the application of these policies and procedures been established?
- Will a DAM system allow recognition of the economic, educational, or intellectual value of digital assets that have hitherto been overlooked?
- Will a DAM system allow the institution to exploit the economic value of its digital content?
- What risks to the institution's digital content are posed by the use of DAM technology?
- How will DAM technology be integrated with existing systems like digitisation systems?
- As DAMS cannot help protect intellectual property rights, what are the IPR implications of establishing a DAM system for the institution?
- As most DAMS do not necessarily provide long-term preservation of digital assets. How will the organisation address this problem?

These questions should provide a profile of an institution's need for and likely benefit from DAM technology. A key starting point is requirements analysis. Before embarking on any development effort, institutions should define requirements precisely in order to determine whether or how the available technologies will meet the needs.

Budget considerations

Budget is likely to be among the top concerns for decision makers looking to introduce a new Digital Asset Management strategy in their organisation. Particular attention will need to be paid to issues of computer hardware, storage (including backup and catastrophe plans), and internal and external communications networks. As previously outlined, DAM packages may be licensed either on a payment-per-seat basis for client licenses (where the organisation pays a set amount for each software licence needed), and with server-centric solutions which allow global and password-protected public access via the Web. Licenses on a per-seat basis can be more expensive than those permitting, for example, a maximum number of simultaneous online connections.

Against the initial outlay required for the system and installation, the potential savings or even gains that may be achieved with the system can be set. The archiving of duplicate objects may be avoided through a considered asset management strategy. Such time savings will have a less tangible, but no less important, effect on the overall ROI. As the costs involved in DAM technology fall, larger organisations with substantial collections will actually stand to profit from a sensible DAM solution, with the rights-management facilities leading to increased and sustainable profitability and usefulness.

Appendices

Appendix I – Brief product outlines[29]

Artesia (www.artesia.com) supplies the *TEAMS* digital asset management system, which can handle both media asset management and enterprise management of video and non-media digital assets, including text, databases and desktop publishing files. The latest version of *TEAMS* offers improved support for video production workflow and expanded support for video formats, as well as 'one click' localisation for international publishing.

Ascential (www.ascentialsoftware.com) markets the *Media360* product, the latest version of which extends the software's existing support for video, audio, image and text asset management, as well as adding new desktop publishing and Web publishing modules. Their integrated solution consists of best-of-class components for each phase of data integration and spanning the full data lifecycle, as well as integration products for automatic data profiling.

Canto (www.canto.org) offers *Cumulus 5.5*, an archiving system that manages and publishes images, layouts, presentations, video, audio and text. The program focuses on assets which are stored on permanent media, such as compact disc or digital video, or which are held on a server, thus facilitating a long-term method of holding, maintaining and retrieving digital assets, changing only the derivatives and never the original assets. The subse-

29 Some product info has been adapted from Adrian Pennington: 'Digital Asset Management: Ready Asset Go' (http://special.northernlight.com/publishing/asset.htm#doc) and from Penny Lunt: 'Put Digital Assets On Call' (http://www.transformmag.com/db_area/archs/2001/11/tfm0111f1.shtml)

quently produced files are then catalogued in relation to the parent asset, thus preserving every derivative and protecting the original from accidental deletion or damage.

Convera (www.convera.com) focuses on search and retrieval of video, image and text files. Convera's *Screening Room* indexes video files, using closed-captioning to assign attributes, in addition to full-text and visual searching. *Screening Room* is able to manage video content to generate a variety of lists, including rough-cut previews, voice recognition-based annotation and improved support for output to editing systems.

Documentum (www.documentum.com) is the leading provider of content management solutions, and provides a wide range of custom-built and packaged technologies for different organisation types and sizes. Documentum provides enterprise content management software solutions that allow 1,500 of the largest businesses in the world to intelligently create and manage all types of content — documents, Web pages, XML files, and rich media — using one common content platform and repository. Documentum has recently acquired the Canadian DAMS vendor, **Bulldog**.

DSpace (www.dspace.org) is a freely downloadable, open-source DAM product which has been developed by MIT libraries in collaboration with Hewlett-Packard. The product provides stable long-term storage needed to house digital products and offers access to all the assets of an organisation through a single interface. The repository accommodates the varying policy and workflow issues inherent in a multi-disciplinary environment. Submission workflow and access policies can be customised to meet the needs of the user group in question.

eMotion (www.emotion.com) offers the *MediaPartner* digital asset management system, which it claims is the only DAM product capable of viewing and annotating media files on handheld devices. The software also includes a natural language search engine.

Extensis *Portfolio 6.0* is geared towards the management of 'live' assets on workstation hard drives. Its cataloguing software makes a database of assets which it dynamically updates as files are added, moved or deleted from the catalogued folders. Searches can be performed in several ways, including keywords, text string, and by file type or creator. The software also includes a Web cataloguing feature capable of building a Website of assets using customisable HTML templates.

Informix (now part of IBM, www-3.ibm.com/software/data/informix/) is an e-business company boasting over 100,000 customers including Disney, CNN and Time Warner. IBM also offers the *DB2* data management software, featuring an industrial-strength enterprise database which can be interfaced with a variety of third party hardware and software. This is an example of a component application that can be implemented as part of a bespoke DAMS solution.

MediaBin (www.mediabin.com) offers a core *Asset Manager* application, which is linkable with companion software modules and applications such as *MediaBin Workplace*, *Cluster Manager*, and *Project Manager*. These products allow a flexible approach to digital asset management, and together they provide powerful tools for managing assets organisation-wide, potentially across multiple servers.

North Plains (www.northplains.com) offers the *TeleScope* digital asset management system, which offers close integration with a variety of media authoring systems and file formats, including sounds, movies, Quark and PDF. According to the manufacturers, this facilitates 'a seamless workflow with media authoring tools that users are already familiar with.' *TeleScope's* enterprise metadata platform supports all emerging metadata schemes, including Prism, SCORM, Dublin Core, ebXML, and others. An additional module provides a Web interface for accessing and modifying the content.

WebWare (www.webwarecorp.com) offers the *ActiveMedia* system, which can either be installed on an organisation's own machines, or implemented as an outsourced (hosted) service. Organisations also have the option of using the product as a stand-alone content management system, or of incorporating it into an existing enterprise system as the backend digital media repository.

Smart Labels and Smart Tags

Executive Summary

Many organisations in the cultural heritage sector are currently engaged in improving their efficiency and offering better services to their visitors, users and patrons. The balance between aims, efforts and costs is often difficult to find. Issues related to the management of holdings are among the core concerns for these institutions, a problem comparable with that of supply chain management in the business sector. Time of delivery, cost and prevention of losses are key factors in both cases.

Improvements in these areas are restricted by the traditional technologies used for tracking items. The current most popular technology, barcoding, has very definite limitations. Even in the cases of using barcodes with detailed records, the necessity to process items through human intervention, leading to space limitation and time constraints, plays a significant role. In addition to this, barcodes themselves can be easily damaged physically.

An increasingly popular alternative to barcoding is the use of *smart tags*, advanced labels based on radio frequency identification (RFID) technology. Radio frequencies are used to read information on devices known as *tags* that can be affixed to or embedded into virtually any object. They either reflect or retransmit the radio-frequency signal. In the cultural heritage sector, holdings of entire collections may be tagged and, in some cases, visitors can be supplied with discrete devices incorporating tags for mobile, instant use.

The use of smart tags leads to increased security, the enhancement of work processes, and improvements in customer service. The introduction of smart labels leads not only to faster checking of the status of a particular item, but can lead to a rearrangement of data processing structures within an organisation. Timeframes for traditional services can change, as can information processes such as the reduction of database queries.

The adoption of smart labels will require investment in:
- *specialised devices* (readers, printers);
- *tags* which are currently more expensive than barcodes, but are likely to get cheaper in the future;
- *staff* training;
- *time* to put tags on the collected items.

The standard, fundamental business aims and benefits of RFID applications are:
- Reduced supply chain costs (through less human intervention, automatic item tracking);
- Enhanced customer relationships (less time on checking and higher accuracy);
- Improved efficiency (better organisation of data management processes).

The current limitations are
- *price:* the unit price per label can be a significant factor. It can vary from 50 cents to several € and is

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therefore currently not suitable for use on items of low value; and,
- *immature standardisation:* the physical data interchange is standardised, but this is not yet the case for the data structures.

A number of organisations in the cultural heritage sector have already adopted smart label technology. On one hand, the technology helps to cover traditional work processes such as check-in, check-out, anti-theft control, inventory and asset management. Libraries, archives and museums may benefit from the technology in managing their everyday work. On the other hand, interesting new studies of visitors' behaviour or innovative guiding services are being launched. This report aims to aid decision makers from the cultural heritage sector in the process of adopting this new technology, and presents the basics of the underlying technologies, a comparison between RFID and barcoding, examples of applications of the technology, and detailed information on suppliers.

An Introduction to RFID Technology

What is RFID?

In general terms, Radio Frequency Identification (RFID) is a means of identifying a person or object based on the use of radio frequencies, i.e. electromagnetic waves that have a wavelength suited for use in radio communication.

RFID technology uses radio frequencies to read information on devices known as *tags* that can be fixed to or embedded into virtually any object, and these tags either reflect or retransmit the radio-frequency signal. Flat, lower cost versions (or *labels*) with embedded ultra-thin RFID tags are usually called *smart labels*. RFID tags and labels are often called 'smart' because of the flexibility provided by the silicon chips embedded into them. In most cases, the tag/label can be programmed and/or reprogrammed in the field, so the same tag/label can be reused to serve multiple functions in a given application. Hence the tag/label is not static like a barcode label; instead it is dynamic in its performance capability. (For the sake of clarity and brevity, tags and labels will usually be referred to just as 'tags' in this report.)

How does it work?

A RFID system will consist of two basic parts – a reader and the tags. The reader performs several functions, one of which is to produce a radio frequency magnetic field by means of an antenna. This field provides the power necessary to activate the RFID tag. In the case of passive tags (without an internal battery) the inbuilt antenna gathers the energy present in the magnetic field and converts it to the electrical energy which powers the embedded integrated circuit. Thus, the memory contents of the circuit (the tag information) are transmitted by the tag's antenna. The electromagnetic signal from the tag is picked up by an antenna within the reader and then converted back into an electrical form. The reader's electronics further process the tag's signal, demodulating the original data stored in the tag memory. Once this data has been demodulated, a microcomputer within the reader can perform error checking and data validation, along with further decoding and restructuring for transmission in the format required by the host computer system. In the case of active RFID tags, a miniature battery provides the power supply for the integrated circuit. When interrogated by the reader, this circuit broadcasts a signal that identifies itself to sensitive reader detection and data transmission circuits. This allows the active tag to broadcast its data at a considerably greater distance than its passive counterpart.

Where is it used?

Potential applications for RFID may be identified in virtually every sector where data are collected. Over the past few years, RFID has begun to move from its early, experimental phase into a mature and proven technology; its inclusion in major consumer applications underlines this. RFID systems may be roughly divided into four groups, according to their applications:

- EAS (Electronic Article Surveillance) systems;
- Portable Data Capture systems;
- Networked systems;
- Positioning systems.

Electronic Article Surveillance systems are typically single-bit systems used to sense the presence or absence of an item. The basic use for this technology is in retail stores, where separate items are tagged and large antenna readers are located at each exit of the store to detect unauthorised removal of the item as in the case of a theft, for instance.

Portable data capture systems typically contain portable data terminals with an embedded RFID reader, and are used in applications where a high degree of variability in sourcing required data from tagged items may be exhibited.

N*etworked systems applications* can generally be characterised by fixed-position readers deployed within a given site and connected directly to a networked information management system. The tags are usually positioned on moving or moveable items.

Positioning systems use tags to enable automated location and navigation support for guided vehicles.

RFID technology is a good example of a technology which assists in the logistical tracing of items. In recent decades, goods moving through a supply chain have been monitored using barcodes. Barcodes, themselves, have limitations which make it difficult for them to meet the needs of many business sectors. Barcodes require human intervention in inflexible conditions in terms of distance from the equipment and orientation of the material. They are easily damaged and can store only the most basic of essential information. Use of a barcode initialises a procedure sending information to a database server and initiating a whole chain of data processing operations.

High demands for speed, cost efficiency and theft prevention are the perfect spur for developing new technologies to minimise the effects of the limitations of barcoding. RFID technology is foremost among these current alternatives. Smart labels provide greater freedom than barcodes. Orientation and distance are less important, human intervention is minimised, labels can store more information and are reprogrammable.

RFID technology works at the forefront of data circulation within an organisation. In this respect, a decision to use it will inevitably influence data management practices within the organisation.

What problems does it address?

The first use of RFID technology dates from the late 1960s. At that time tags had a memory capacity of only one bit, and were used exclusively as electronic article surveillance (EAS) anti-theft deterrents. This first application area shows a typical problem that continues today.

The technology developed rapidly in the labs in the 1970s. During this period there was much development with a view to transport use for vehicle tracing, as well as in animal tracking and warehouse automation in factories. Most of the patents relating to RFID originate in this decade.

RFID technology continued to develop throughout the 1980s, and was implemented widely for many different purposes. Applications in the cultural heritage sector had not yet been considered, but this growing use was to inspire future work in that direction. In the late 1990s, fully formed applications in fields such as toll collection, supply chain management, access control, and vehicle and animal tracking became a reality. In this decade the design and functionality of RFID technology was expanded, and led to the construction of microwave RFID tags consisting of a single integrated circuit. The potential memory capacities and read/write capabilities were enhanced further; a step which increases the possible applications for which this technology can be deployed in cultural heritage institutions. **Checkpoint Systems Inc.** made the first installation of RFID technology in the library sector in 1998 at Rockefeller University Library.

The application of RFID technology leads to additional benefits in relation to information management, and this may be of particular relevance to cultural heritage organisations considering implementation of the technology. One benefit of crucial importance is the ways in which RFID technology may be connected with the integration of legacy data management systems.

The basic on-going work within the cultural sector tends to be targeted towards inventory management, including check-in and check-out of holdings, and issues of security. It is clear that this range of applications supports the work of libraries, museums and archives. Museums are organisations with a specific mission which could benefit from this technology in more creative ways than mere stock management. In addition to inventory management, museums could utilise the technology to provide guided tours for visitors, to study the performance and application of cultural agents and 'avatars' (virtual agents), and for electronic programming guides and personalisation. (These areas will be covered in more detail in DigiCULT Technology Watch Report 2.)

Barcode Technology

The Universal Product Code, or *barcode*, was designed in the early 1970s to speed up checkout processes in shops. The product has also helped manufacturers and retailers keep track of their inventories, giving valuable information about the quantity of products being bought and, to a certain extent, about who is buying them. This code acts as a kind of 'product fingerprint' composed of machine-readable parallel bars that store binary information.

Barcode technology has been widely used in the heritage sector, especially for library labels. Such labels typically contain a barcode, a human readable number and an alpha field containing the name of the library or institution. Developments in the technology allowed for an extension of the content and functionality of the labels.[30]

30 Barcoding technology has advanced to the point that some two-dimensional codes can store up to 1.1 KB of machine-readable data.

A label serves three purposes: it identifies the book as library property; it provides a unique number for location of that specific book; and it provides a means for automatic data collection. Thus libraries are able to conduct inventory management and develop online public access catalogues from the books themselves. Users will be able to browse the shelves with bar wands which can store bibliographic information that is downloadable into whatever final product they wish. Publishers also benefit as buyers have more complete usage information available at the time of publication. Booksellers benefit by being able to organise the books without the use of additional computer programs and staff. Buyers benefit through the use of handheld scanners with screens so they can scan a book and obtain a comprehensive bibliographic record, and then download those records into a computer to generate a printout. Nevertheless barcode technology has a number of limitations and does not meet tomorrow's needs for a number of reasons:

- They are prone to damage;
- They require human intervention to operate the scanning device; and,
- They cannot be programmed, and can provide only the most basic product number information.

RFID and Barcodes – a comparison

Smart tags and labels may be considered as an intelligent barcode replacement with the following advantages:

- RFID tags don't require line of sight or close proximity to the reader in order to be read;
- RFID tags are (re)programmable; and,
- RFID tags are physically durable and not susceptible to damage from dirt, grease or water.

The price of RFID tags does inhibit their use extensively within a retail environment where goods prices are low. They are applicable for higher priced goods, particularly those vulnerable to theft. As the use of RFID tags increases, their cost is expected to reduce significantly, opening new business application opportunities.

RFID complements barcode technology in a growing number of applications. Implementation of RFID systems is on the rise as the price of smart labels such as the mid frequency passive tags is decreasing for mass deployment. Standardisation will aid an even stronger growth in RFID installations.

Feature	Barcodes	RFID
Type of record	Read only	Read only and Read/Write
Use	Mostly does not store data, but points to a database. New versions can store data	Stores data
Placement	Requires line of sight	More options: can be read through covers
Direction for reading	Reading only in one direction	Can be read in any direction
Static/dynamic use	Reading only in static position	Can be read while moving
Simultaneous usage	Reading one by one	Several tags can be read simultaneously
Distance	Ray of light	Currently from 5 to 700 cm (for our wave range)
Cost	< 2 cents	50 cents – €1
Damage	Damaged more easily	For commercial use tested extensively; not damaged even in harsh open-air environment
Use on metal surface	Possible	Tags must be separated from metal surfaces by a dielectric material

Not all tags can be mounted on metal surfaces and where they can the possible read distance is reduced. *OneTag* is an example of a current product which separates the tag from the metal surface with a dielectric intermediate layer. In Case Study III we give an example of a library which scanned and printed book covers, removing metal ones when necessary in order to utilise the technology.

To illustrate clearly the difference between use of barcodes and smart labels, here is a sample scenario.

In the case of barcodes which allow storage of structured data in addition to identification number, the movement of an item within a collection may be done following several steps:

1. The record for the item is edited to change its status.
2. The item's identification number is given to the staff member who will make the change.
3. A desired new location is specified and supplied to the staff member who has to make the change.
4. The staff member swipes the barcode on the item.
5. The computer system retrieves the relevant record. New location data is entered.
6. Staff member makes the physical change of place and swipes the barcode at the new location. This updates the record in the computer system with the new location code.

If this item was supplied with a rewritable RFID tag, the item's location can be edited on the tag directly and the computer system will have only to be updated with the new location. When the item is moved, the tagging station is used to update the record.

Currently, barcodes and RFID co-exist in the cultural heritage sector. Libraries which introduced RFID technologies (like Santa Clara City Library, California, Case Study III) report that after the introduction of the new technology, 30% of library materials were

checked out using the express check machines. While the RFID technology shows some problems (see Case Study II, below), barcodes would serve as a safety net of some kind.

RFID is a relatively new technology, but it is being actively promoted. It has been touted as a replacement for all barcoding technology applications. Actually, in the cultural heritage sector the real answer is not to choose either smart labels or barcodes for *all* applications, but to determine which one fits best the requirements of a specific business need. In some innovative museum applications, which involve tracking people or items *from a distance* without disturbing the people or checking each item with a wand, RFID is an obvious choice. In cases where the basic aim is to implement a system to check-out items from a collection or maintain good inventory control, the essential technological features are different.

Not all of the advantages of smart labels truly add value to the management of library collections when compared with the initial investment and subsequent costs. The cost of the labels is still the biggest expense in the introduction of RFID technology.

Among benefits of RFID it is worth mentioning that the lack of the line of sight requirement results in lower perceived intrusive presence of staff and an improvement in privacy. Tolerance of a harsh environment and tracking items in real-time could be of great importance in cases of fire and floods, but may not be essential for general day-to-day work. Long read range also helps in minimising staff involvement and aids security. Multiple tag read/write is crucial when writing new content, and will facilitate information management in organisations, though in some collections the ability to add new items would be more valuable than the ability to change the contents of existing tags. The basic benefits in libraries relate to personnel management and organisation of the information processes. These could be improved to an extent that would justify the costs of the implementation of RFID.

The performance of RFID equipment does not yet equal that of barcoding. Reported real-life cases of unstable reading stations and problems with the readability of labels are significant and should be monitored. In addition to this, barcodes are usually smaller in size than smart tags, and are often easier to apply to the variety of items in cultural heritage collections.

The state of standardisation

One of the reasons for the slow adoption of RFID might be the lack of mature and widely adopted standards. Some application fields have developed their own standards, for instance ISO 11784/11785 an Animal Identification RFID standard and ISO ANSI NCITS T6 256 – 1999 an Item Management RFID standard. The standard ISO/IEC JTC1/SC31 19762 Part 2: *Radio-Frequency Identification (transmission)* is still under development. Standardisation in the cultural heritage sector is not yet mature, although work on a smart label standard for museum applications has been carried out within the frameworks of the **CIMI** consortium (see Case Study IV, below).

Ultra Wide Band and eTen

Ultra Wide Band (UWB) consists of the use of extremely short RF pulses instead of continuous waves to transmit information. The pulses directly generate a very wide

bandwidth signal. UWB is an old, though not yet mature technology with the potential to impact significantly on traditional ways of managing the spectrum.

Some applications of UWB are in:

- Short-range radio;
- High speed (ten Mb/s) WLAN's;
- Precision geo-location systems;
- Industrial RF monitoring systems;
- Collision avoidance systems;
- Motion and intrusion detection radar;
- Automobile and aircraft proximity radar and precision landing systems;
- Subsurface or ground-penetrating radar.

Of these applications, two offer opportunities for near-term commercialisation and are therefore fitting candidates for an *eTen* application. These applications are based on the ability of UWB to overcome the inherent limitations of narrowband communication in in-building and cluttered environments, and UWB's known and tested localisation and positioning application.

Current approaches in the cultural heritage field are mostly based on wireless or infrared hand-held devices. There has been speculation and experimentation with the use of normal GSM (Global System for Mobile communication) technology, sometimes calling directly to an individual's number. For the most part these approaches have been less than successful. While galleries are often open spaces allowing for the free use of such technology, historical sites, particularly those with outdoors environments, or closed locations such as tunnels and galleries offer distinct challenges to the current technology.

In the travel, tourism and cultural heritage market there is a need for cheap, efficient and easy-to-use handheld devices that allow the user to access additional information about a historical object, a statue, a building or in the case of museums and galleries an exhibit. One difficulty of a 'taped' message system is that the user has to identify the object of interest, and then input a code to receive the relevant message. The user of a hand held device in a museum is fed the information on the exhibit automatically when he or she is in front of the specific exhibit, determined through the positioning abilities of the technology.

An added advantage of the system is that from a security standpoint the museums also know who is where in each room thanks to the localisation application of the technology. This allows a passive security system to monitor the progress and the location of visitors. The application has great market potential. The use of a positioning and localisation application to identify where individuals are in buildings allows institutions to ensure that security has not been breached, or that individuals are not attempting to enter secure or off-limits areas.

Another interesting application of the positioning and localisation abilities of UWB is in transportation and logistics, where it can be used to determine the location and the movement of specific shipments that are on rail cars, trucks or in warehouses. If UWB transmitters are placed inside containers, the location and the shipments of all of these containers within a large container yard can be determined almost instantly. Beyond the

31 http://www.vdc-corp.com/

location, the security application also shows if these shipments have been contaminated, or if the container has been breached and if someone is inside, thereby deterring theft and the illegal movement of people.

Current scope and future development of the technology

According to Michael Liard, RFID/AIDC Analyst at Venture Development Corp[31], the expected annual growth in the RFID sector is 24%, although this estimation does not distinguish between different types of applications. Current distribution of the costs for hardware, software and services shows that greater share of overall expenditure on RFID technology implementation is spent on transponders (nearly 51%). In the long-term, one of the natural expectations is that the price of the tags will drop, which ought also to influence this share. Readers make up about 23% of the expenditure, the software share is 5%, and services account for 21%. RFID technologies are implemented most actively in the US (used in 47% of shipments), followed by Europe (34%). The cultural heritage sector is not one of the faster growing economic sectors. These include retail, commercial services, and health care. The fastest growing application segments are reported to be point of sale, rental item tracking, baggage handling, real-time location systems and supply chain management.

Expected future improvements should influence such parameters as *read range*, *read rate* (the number of tags per second), *cost* (especially that of the tags themselves), and *memory capacity*.

Current applications of RFID tags – Tabular Overview

Application area	Typical application	RFID type(s)
Manufacturing and processing	Tracking of items throughout the manufacturing process	Passive Tags
Assembly	Tracking of items throughout the assembly process	Passive Tags
Warehouse management	Optimisation of space use, inventory management, automated picking and sorting, anti-theft	Passive Tags
Asset management	Automated identification of assets, inventory	Passive Tags
Airline	1. Automated luggage-handling system 2. Access control to secured areas 3. Aircraft components can be tagged to ensure accurate maintenance schedules	Smart Labels Active Tags Passive Tags
Transport	Goods can be tagged and identified from loading to delivery, precise shipping, and container tracking	Passive Tags
Automotive industry	Manufacturing line control, distribution control	Passive Tags
Logistics	Management of FMCG items, pallets, cartons, totes, returnable containers, gas cylinder tracking	Passive & Active Tags
Security	1. Electronic article surveillance (EAS) 2. Car immobilisers 3. Real time location systems	Smart Labels Active Tags Active Tags

Application area	Typical application	RFID type(s)
Pharmaceutical	To manage the movement of medications and containers through assembly and packaging lines	Passive Tags
Auto service	Car parking, car washing, car rental, car fuelling	Active Tags
Brewery	Identification and tracking of beer kegs from the point of dispatch to their return	Active Tags
Food processing	Automated control and inspection in meatpacking facilities	Passive Tags
Postal tracking	Automated parcel delivery process	Passive Tags
Mining industry	Tracking of employees and locomotives in and around the mining area for safety and security purposes	Active Tags
Automated vehicle identification (AVI)	Automated toll collection system	Active Tags
Cattle/Dairy farming, livestock ID	Identification of cattle enabling accurate records for automated farm management	Active Tags
Hospitals and health care	Fast, reliable inventory control of costly medical equipment, tracking medication dispensing, lab samples, blood bags, access control of patients	Passive & Active Tags
Government buildings, office buildings	Inventory control of equipment such as computers, printers etc., time and attendance (employee identification)	Passive & Active Tags
Schools	Inventory control of equipment such as computers, printers, etc.	Passive Tags
Document management	Document tracking	Smart Labels
Libraries	Anti-theft, book inventory, to streamline the flow of books, statistics gathering, to speed check-in and check-out	Smart Labels
Museums	Inventory, statistics gathering, talking tags, anti-theft	Passive & Active Tags
Archives	Inventory, item flow control	Passive Tags
Public services	Industrial laundries	Active Tags
Video stores	Automated detection of shoplifted items, inventory control	Passive Tags

Anticipated future applications of RFID tags – Tabular Overview

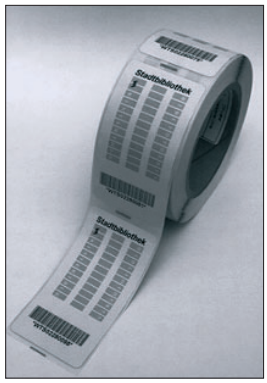
Application area	Typical application	RFID type(s)
Public transportation	Smart tickets	Active Tags
Home appliances	Smart electric appliances	Active Tags
Electronic equipment manufacturing	Tags with equipment specifications enable easy upgrading	Active Tags
Waste management	Automated recycling, landfill management	Active Tags
Manufacturing	Synchronised factories, unmanned factories	Active Tags
Access control	Affinity cards, controlled access to facilities	Active Tags
Airline	1. Access control to secured areas 2. Aircraft components can be tagged to ensure accurate maintenance schedules	Active Tags Active Tags
Auto ID-Centre	Internet of things (T2T)	Passive Tags
Sports and recreation	Sports timing, billing customers per lift ride	Active Tags
Pharmaceutical	Talking tags for blind and visual-impaired	Active Tags
Amusement park and event management	Cashless payment, guest identification	Active Tags
Hospitality	Guest identification and issuing membership cards in hotels, restaurants	Passive Tags
Document management	Tags containing ID and biometrics data (fingerprints, photo) for electronic passports	Passive Tags

How RFID Technology Works

The Fundamental Components

An RFID system will typically include the following components:

- An RFID device (transponder or tag) containing data about an item;
- An antenna used to transmit the Radio Frequency (RF) signal between the reader and the RFID device;
- A reader that receives RF transmission from an RFID device, and passes the data to a host system for further processing;
- Application specific software.



by courtesy © info@bibliotheca-rfid.com

RFID Book Labels, showing the Winterthur library logo and an individual barcode)

In addition to these, organisations considering bulk tagging of their existing items will require tagging workstations, i.e. computers connected to a printer capable of printing the tags.

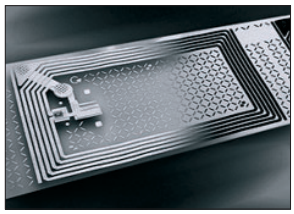
Tags

Historically, an RFID device that does not actively transmit to a reader was known as a tag, while a device capable of actively transmission was known as a *transponder* (TRANSmitter + resPONDER). Today the terminology has become interchangeable, with RFID devices referred to variously as tags or transponders. For clarity, in this watch report RFID devices that actively transmit to a reader will be termed *active tags* and RFID devices that only reflect radio signals are termed *passive tags*. In general, active tags use a battery to power the tag transmitter and receiver. The lifetime of such tags is directly related to battery life which is often in the range of three to 10 years)[32]. Passive tags generally obtain their power supply from the radio frequency signal generated by the interrogation unit. The battery-free tag operation lasts the life of the product or system in which it is embedded.

RFID tags can be divided into two further categories:

Chip-containing tags are fabricated as low-power integrated circuits suitable for interfacing to external coils, or utilising 'coil-on-chip' technology for data transfer and power generation (passive mode). The basic components of a chip containing tag are:

- Digital circuitry (microprocessor, control logic, security logic);
- Memory (ROM, RAM, non–volatile EEPROM). ROM-based memory is used to accommodate security data and the tag operating system instructions. RAM-based memory is used to store temporary data during the processes of interrogation and response. The non-volatile programmable memory may take various forms, with EEPROM being typical. It is used to store the tag data and needs to be non-volatile to ensure that the data is retained while the device is in power-saving mode;
- Analogue circuitry (data transfer, power supply);
- Tag antenna. This is the means through which the tag senses the interrogating field and, where appropriate, the programming field. The antenna also serves as the means of transmitting the tag response to interrogation. Tags will generally employ one of the following types of antennae:
  - Electric antenna. The antenna is of printed dipole type and is used typically in the high frequency range – 2.45 GHz;
  - Inductive antenna. The antenna is made of etched wire or copper/aluminium wire wound in a circular pattern on the tag. These coil antennae can operate at 125–134 KHz as well as at 13.56 MHz;
  - Capacitive antenna. In this case, a small amount of conductive carbon ink will typically fulfil the duties of the antenna. It is applied to the paper substrate via conventional printing methods. These antennas operate at low frequencies such as 130 KHz;
  - encapsulating material to protect the chip from harsh environments.



Inlay (Lucatron), Antenna with BiblioChip™

32 This longevity is appropriate in supply chain management, but not in the cultural heritage sector.

Chipless tags use different technologies, based on different physical principles, such as printed or bonded inductors (capacitors or diodes), fibres, thin films, microwave reflectors, remote magnetic, transistor or transistorless circuits.

Chip-containing tags cost more and do more with data. They can store larger amounts of data, up to 10K, compared with chipless tags which generally hold 32 or 64 bits. Chipless tags are much cheaper but currently cannot hold as much data without being unacceptably large for their purpose.

Depending on the memory types embedded in RFID tags, the tags will typically fall into one of following categories: read–only, read–write (R/W) and write once/read many (WORM). Read-only tags contain a unique factory-programmed ID code, consisting of bits or digits which cannot be altered later. They offer the lowest cost and lowest level of data volatility. WORM tags are essentially read-only tags, except that the memory content may be inserted – once only – after manufacture. Read-write tags can be programmed by the user to revise and update data. Thus, a custom coding and numbering system can be used and data can be easily integrated with other computerised systems.

Data collected from either type of tags can be sent directly to the host computer, or stored in the reader until such times as it can be conveniently uploaded to a computer for data processing.

Data types

RFID technology uses two extremes of data storage. *Unique Signature tags* do not store any data, instead the reader's electronics simply sense something unique about the product, and 'point' to records held in a database. At the other extreme, *Digitally Encoded tags* store digital information according to agreed rules, so that readers can retrieve information directly from the tag without the need to refer back to a centralised database. This latter feature should be carefully considered in the cultural heritage sector, and others, as it influences all data processing procedures within the organisation.

Operating Frequencies

RFID devices can be divided into low-frequency and high-frequency tags. Low-frequency tags typically provide slower data transfer and operate over shorter distances. High-frequency devices, on the other hand, can work at greater distances and at higher relative speeds. While RFID systems may vary by country or region, RFID tags will typically utilise the following frequency range:

- Low frequency: 30 to 300 KHz frequency range, primarily the 125 KHz band;
- High frequency: 13.56 MHz frequency range;
- Ultra high frequency: 300 MHz to 1 GHz frequency range;
- Microwave frequency: frequency range above 1 GHz, primarily the 2.45 GHz and 5.8 GHz bands.

Operational Range

The range of tags varies widely but for all types a general rule of thumb is the greater the range required the more expensive the tag. At a range of just a few millimetres, an RFID tag can be embedded in objects for high-speed sorting and authentication, but for logistical purposes a range of up to one metre is often required. Other applications for real time location can require read ranges of several kilometres.

by courtesy © info@bibliotheca-rfid.com

Sensors (Gate reader) with three antennas (Winterthur library)

RFID Readers

Readers can differ considerably in complexity depending upon the type of tags being supported. Functions performed by a reader may include quite complex signal processing, parity error checking, data correction algorithms and sophisticated polling techniques. An outstanding feature of readers is their anti-collision capability, thus ensuring data integrity when several RFID tags are read simultaneously.

Generally all RFID readers share the same basic architecture:

- An antenna (a coil or wire in a housing with a driver board);
- Reader electronics consisting of a decoder, data converter, and computer interface (RS 232, RS 422, RS 485, Ethernet);
- Power supply;
- Portable readers have the same basic architecture as other RFID-readers but their elements are typically enclosed in a single hand-held unit. Portable readers often draw power from their host.

RFID Tag Programmers (Writers)

Tag programmers are used to deliver data to R/W and WORM tags and the programming itself is generally carried out off-line, though some systems are capable of re-programming on-line. In such cases, the functions of the programmer are combined with those of the reader – these are often called 'reader-writers'. The range over which the programming can be achieved is generally less than the read range. Programmers are also generally designed to handle only a single tag at a time, despite the capability for multiple simultaneous reads.

Smart Label Printers

Smart label printers enable users to create smart labels on demand and encode them with information of different kinds. Printers use label stock that incorporates blank RFID integrated circuits sandwiched between the surface face and the adhesive layer. The integrated circuit may be so tiny that it is invisible to the human eye.

Smart label printers function in traditional thermal mode when creating barcodes, graphics or text. They also have RFID encoders and readers embedded. Before the label is printed, the RFID data is encoded on the tag which is subsequently read to ensure

data accuracy. The label is then fed forward for printing. With most printers, an error message prints over the label if the tag does not read or its data does not verify, thus voiding the label's use. Tags are made from flexible material that does not damage the print head.

The encoding and verification processes, which may take milliseconds to several seconds depending on the amount of RFID data and the type of tag, makes smart label throughput somewhat slower than barcoding.

RFID Technology and the Heritage Sector

Brief Background

It is not surprising that, within the cultural heritage sector, libraries are the organisations that have most widely and readily adopted RFID technology so far. Libraries have the most pressing need to organise and safeguard large numbers of moveable objects, and barcode technology is utilised in libraries more than anywhere else in the sector. The applicability of RFID technology in the library environment is not difficult to see; what may be less obvious are the potential uses of the technology in other types of institution.

RFID technology has already been employed to impressive effect in a number of different sizes and types of organisation, including museums and visitor centres. The case studies and scenarios that follow should give a reasonable picture of the current state of play, as well as an indication of how the technology may affect different areas of the sector in years to come.

As unit costs continue to fall and the labels themselves become physically smaller, future applications of this technology may be only as limited as people's imaginations.

Case Studies

Case Study I – NetWorld Exhibit, Museum of Science and Industry, Chicago IL (www.msichicago.org/exhibit/networld/networld.html)[33]

Chicago's **Museum of Science and Industry** (MSI) is the oldest institution of its kind in the Western Hemisphere, and the seventh most popular museum in the United States of America. The MSI attracts around two million visitors each year, approximately 20% of whom are children from school groups and other youth organisations.

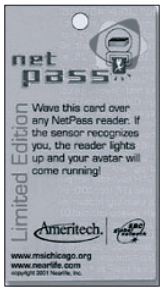
The museum's planning team wanted to introduce a new, permanent exhibit, attractive to children and adults alike, which offered a hands-on guide to the Internet and an explanation of some of the fundamental technologies that lie behind it. Core learning objectives included demonstrations of the digitisation process, bit streams, and the concept of networks. Interactivity was felt to be an essential component of any successful

33 This case study is based upon a telephone interview with Dr Barry Aprison, Director of Science and Technology at the museum. The interview took place on 05/11/2002.

solution, particularly since the exhibit is geared more towards younger visitors. Other goals for the technology were personalisation and, since the exhibit is permanent, longevity. The introduction of personalised 'avatars', unique digital manifestations corresponding to each user, was a key goal. The ability of multiple avatars to traverse the exhibit simultaneously, following their corresponding users by tracking which of the exhibit's twenty interactive stages the visitors were engaged with at any given time, was central to the overall requirements of the system.

To this end the museum selected **Motorola's** *BiStatix* RFID tags based on their long proximity range, about 5cm, and acceptable unit cost of the tags (initially around €1.15, but since fallen). A further benefit of the **Motorola** tags was the potential for using a lenticular surface on the surrounding 'NetPass' cards, providing an optical illusion similar to a hologram and thus further increasing their attractiveness.

A specialist interactive development company, **Nearlife**[34], was brought in to assist with the design of the exhibit itself, and the RFID tags and interactive software were brought together by a dedicated integrating team (**Superior Exhibits and Designs**, Elk Grove Village IL, no URL available). When visitors enter the NetWorld exhibit, they are photographed and their faces are digitally mapped onto a standard avatar 'body'. As they move through the exhibit, the visitors move their **NetPass** cards near to one of the *BiStatix BXR-610* readers, and their counterpart avatar travels across a 30-foot long touchscreen display to meet and interact with them.



© ID Systems
The NetPass card

A variety of different groups were involved in the creation of the *NetWorld* exhibit, including designers, architects, software programmer, systems integrators and the museum's own planning and technical staff. The introduction of the RFID elements was among the simpler tasks faced by the museum, and few problems were encountered with the smart tag technology. Before the exhibit went live, the **Nearlife** development team and the system integrators each provided basic training for visitor demonstrators as well as helpful documentation for the museum's technical staff. The entire procedure, from initial planning to final implementation, took three years, and the *NetWorld* exhibit opened to the public on March 2nd 2001.

The chief difficulty management has encountered with the technology is in persuading visitors to pay the extra $2 for a card after they have already paid for admission to the museum. It is possible to travel through the exhibit without using a *NetPass* card, but much of the intended interaction is lost and the learning objectives are not met to their fullest potential.

It has been found that when members of the museum staff are on hand to demonstrate the system, the proportion of visitors buying the cards increases significantly. Although a formal evaluation of the exhibit has not yet been carried out, informal comments and feedback suggests that visitors who opt to buy the *NetPass* cards tend to see it as a worthwhile investment, especially since their avatar is stored permanently and may be recalled on subsequent visits to the museum.

Another benefit of the combination of RFID tags and the other technologies employed in the exhibit is the increased extensibility that they offer when used in conjunction with one another. Proposed future uses for the tags include extending their

34 Nearlife, Cambridge MA, http://www.nearlife.com

range to welcome visitors at the museum's front door, and subsequently sending an automatic email message so that when they return home in the evening there is a message from the museum waiting for them, and thanking them for their visit.[35]

The major technical difficulty encountered by the museum lay with the card vending machines[36], which jammed frequently in the early stages. The machines were soon adjusted to manage the stacks of cards more reliably, and staff discovered that the stacks had to be loaded in a certain way to prevent frequent failures. The RFID technology itself, which resides *within* the card, posed few problems for the museum's technical staff. It has been found to be both robust and reliable.

The museum is currently looking into alternative ways of vending and promoting the cards, in order to maximise visitor take-up. Having staff on hand at all times to demonstrate the benefits is expensive, and is not felt to be the most efficient use of staff time. A new and more involving vending machine, featuring integral graphical panels for demonstration purposes, is currently in the works. The prospect of dropping the price of the *NetPass* cards, or even making them free, has also been mooted. It is hoped that these moves will entice more visitors to experience the *NetWorld* exhibit in the most full and rewarding way possible.

Case Study II – Saïd Business School, University of Oxford (www.sbs.ox.ac.uk)[37]

The **Saïd Business School** has recently relocated into a new, purpose-built building. The school's new library has inherited over 21,000 books and journals from its previous location, and a security system was immediately required in order to prevent unauthorised removal of books and other moveable items. In addition to this primary objective, the system was also required to facilitate stock management and inventorying, as well as allowing borrowers to issue and return books themselves in a quick and straightforward way.

After consultation with colleagues in the library, which has seven full-time members of

The reading room at Saïd Business School

35 This could be considered a novel application of Customer Relationship Management.
36 From American Vending Sales Inc, http://www.americanvending.com
37 This case study is based on a telephone interview with Ms Fiona Richardson, the Library's Information Services Manager, which took place on 03/11/2002.

staff, and the rest of the department, the technology selected to meet these needs was **Intellident's** RFID solution, which consists of a set of smart labels with each chip holding a unique identifier and a dedicated anti-theft bit. Sets of RFID security gates were installed at the library's entrance, with both audible and visible alarms activated when an item was taken through without having first been correctly checked out. A self-issue station, consisting of a PC and an RFID reader, is a key component of the system, and this station has been interfaced with the library's existing Management Information System (from **Geac**, www.geac.com) in order to track and manage the whereabouts of particular items.

The only potential alternative solution to the problem was the use of old-fashioned electromagnetic tags. Although cheaper, these tags do not have the range of functionalities that RFID technology can offer, and are increasingly considered to be unsuitable for the future. Smart labels offer much extensibility for future uses, and the library has plans to build on its existing functionality with, for example, stock management improved and expanded using the technology now in place. It is also expected that the unit cost of smart labels will continue to fall steadily as they are bulk manufactured, while the hardware required for RFID technology is already significantly cheaper than its electromagnetic counterpart.

The ultimate decision to run with RFID rather than electromagnetic tags was made by Ms Richardson, the Library's Information Services Manager, herself, though other staff at the library were consulted to ensure they were aware of the benefits and potential risks involved in the introduction of this new technology. To begin with, all of the existing permanent stock was batch-tagged by library staff, casual workers and volunteers. In a larger library this would have been an enormous imposition, but given the Library's relatively modest size the 'blitz' approach was feasible. It was decided that ephemeral material such as newspapers and some weekly journals would not be tagged immediately, given the significant cost of each label.

After a good start, the implementation of the system became fairly problematic. The security gate alarms sounded erroneously, and when this became a frequent occurrence the library staff felt that both they and the system were beginning to lose credibility among the students. It goes without saying that a noisy alarm is irritating and distracting in a traditionally quiet library environment. In time, these problems were overcome and the staff realised that the labels must be checked in and out slowly and carefully to avoid triggering the alarm, although less care and accuracy is required with RFID than with comparable electromagnetic systems.

One essential lesson learned by the library was that the integration of new and legacy systems is crucial. As well as the digital catalogue, the RFID system is also connected to the university's CCTV security system, allowing unstaffed access to students. When the alarm sounds outside the regular staffed hours, a closed-circuit camera is triggered to record the event, and off-site security staff are alerted. RFID thus permits the library to offer longer opening hours, a frequent request heard from students, and frees the librarians to spend an increased proportion of their time attending to more rewarding duties than acting as stand-in security guards.

It is anticipated that the range of functionality of the new system will be expanded in time to include more detailed inventory control and stock management, and the introduction of hand-held readers will significantly reduce the time taken to track down missing books. Rather than going through each shelf item-by-item, a library assistant will eventually be able to walk down each aisle and wait for a signal from the reader telling him that the errant book is shelved nearby.

Case Study III – Santa Clara City Library, Santa Clara, CA (www.library.ci.santa-clara.ca.us/)[38]

In early 2000, **Santa Clara City Library's** management team had to choose between the legacy **Checkpoint** radio-frequency system or a move to a magnetic strip system. The basic concern in the first case was the inadequacy of the self-checking system. The latter option raised concern over having to handle the entire collection in order to place a magnetic strip on each object. Given the size of the collection (about 317,000 items) this was an issue of great importance. While these matters were discussed, the supplier of the legacy system in the library[39] announced the availability of their *Intelligent Library System* (ILS) based on RFID technology. By June 2000, when its implementation at Santa Clara started, it was installed in 17 sites and used in the tagging of over one million books.

The Santa Clara City Library decision makers familiarised themselves with the experiences of Rockefeller University Library, the first library in the world to install an RFID system.[40] Material handling time was reduced by an average of 75% according to reports from libraries that have applied the **Checkpoint** solution.

City Librarian at Santa Clara, Karen Rollin Duffy, has said: 'We're currently building an 80-thousand-square-foot library and wanted to be sure that the library system we selected takes full advantage of the most sophisticated technology available, that's why we opted to work with **Checkpoint**. By automating our check-in/check-out process, **Checkpoint's** ILS will free up our staff to interact with patrons and provide a hands-on level of service that would otherwise not be possible.'[41]

The library management had a clear idea why **Checkpoint** was an appropriate choice:

- It is a new technology with the potential for multiple applications in the future;
- It is a flexible technology combining security and item identification in a single tag;
- It is designed to work efficiently with a materials sorting system, which will help with automating the check-in procedure;
- Its user-friendly self-check machines allow simultaneous multiple item check-out.

Given these factors it was expected that the library's staff would be freed to spend more of their time consulting visitors and patrons.

The system purchase was made in May 2000, with a schedule for tagging the collection by November 2000. **Checkpoint** organised training in the use of the tag programmers over a two-day period. Within one week, a staff of eighty was trained to program tags. In addition to this, a Security System Committee was at work determining the best work processes in the new environment.

The library set up six tagging stations, with an overall estimate of tagging time of around two minutes per item for books. Audio-visual items take the same amount of time for programming the tags, but slightly longer to affix them due to the variations in format.

Initially, **Checkpoint** had recommended taking the tagging station to the shelves. The library staff decided not to do that for several reasons. The process can be noisy and the management felt it was not a good idea to generate noise in a public area of the library. The tagging station consisted of a regular sized PC, a staff station reader and a 'reader

38 This case study is based upon the content of the web sites of the Santa Clara City Library and Checkpoint Systems Inc, visited on 01/11/02 and 19/11/02.
39 Checkpoint Systems Inc, http://www.checkpointsystems.com
40 http://www.rockefeller.edu/library/
41 See http://www.checkpointsystems.com/downloads/word/library/santaclara.doc.

wand'. Quite apart from the noise, moving this equipment through the library stacks would be cumbersome. A third argument against **Checkpoint's** suggestion was the desire not to make public the means by which library holdings are secured.

Check-out and check-in were made simpler with the new technology. In the case of check-out, the process was as follows:

1. Use barcode reader for library card;
2. Pass book over staff station reader – one at a time until transaction complete;
3. All Circulation stations with staff station readers are connected to the server; and,
4. Tag information is passed by the gates/antenna to the Server and added to the list of checked-out items.

The new system was launched in October 2000, one month ahead of schedule. The system was introduced to library visitors in three easy steps – (1) touching screen and checking library card; (2) passing items over shelf; and (3) collecting a printed receipt.

Among the reported positive results were:

- Check-in and check-out do not require the extra security step of sensitising and desensitising;
- Healthier staff, due to the reduced motions involved in check-in and check-out;
- Simpler procedures, fewer steps in check-in and check-out;
- Easy self-check, special book and barcode positioning not necessary;
- Theft information, with information on the item that triggers the security gate;
- The ability to secure magnetic material without separate equipment, and new video tag allows the tag to be placed inside the videocassette itself.

The library also expects further benefits:

- Future use of an inventory tracking device for quick and easy item information gathering;
- Future use of a sorting system, such as *TechLogic*.

It took about six months to convert 98% of the circulating books. A small number of items were deliberately not tagged because they were in such poor condition or had a very short expected lifespan. Videos, CDs and audio-books have taken longer, as these were often on reserve. The variation in sizes, shapes and formats of audio-visual material made affixing tags a challenge.

The library reported a tag failure rate of less than 1% overall. Some tags failed for undetermined reasons. Some failures were attributed to 'bad tags', and some to operator error in the initial programming. Two of the staff station readers were found to be 'less sensitive' than the others, and would not read certain tags although when they were tested on another machine the tags were read correctly. The technology provider replaced these defective stations. The types of library materials which are more likely to have failed tags include children's board and paperback books. Books with metallic covers prevent the target from reading[42]; for those objects new covers were scanned and printed.

After one year of use, approximately 30% of the Library materials are checked-out using the express check machines. This figure has been increasing each month, as more patrons become familiar and comfortable with the machines.

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42 There are now tags that are specially designed to be used with metallic materials (see above).

Case Study IV – CIMI Consortium: the Development of a Museum Standard[43]

Taking into account the developments and expected applications of Smart Labels, the **CIMI Consortium** initiated work on a standard to serve museum needs. A proposal is available on its Web site[44]. The standard was to be made public by mid-2001, but was awaiting publication as we prepared this case study (November 2002).

As Smart Labels become increasing affordable their use by the museum sector should become more widespread. As more museums begin using them institutions will require guidance about how to make best use of the limited storage space on the chip. A CIMI Consortium group worked on standards proposal to establish a solution which would help museums of different types and sizes to the best and most compatible use of the limited chip storage capabilities. A basic principle was formulated: '…the standard should be device independent: it just answers the question how to use the limited storage capacity on smart devices in a flexible and interoperable way.'[45]

The development team found the following requirements critical: flexibility allowing storing of different types of information in the same chip, dependent on specific application requirements; interoperability between different software applications used within the museum and between different collection management systems; and extensibility with a view to the inevitability of future technology development.

Museum data poses unique types of problems. This is especially true when the information management needs of museums are compared to those of libraries. The structure of data to be stored is also more complicated, taking into account that the *Spectrum II* standard consists of more than 400 individual fields.[46] The group working on the proposal took into account the fact that current smart labels technology has limited memory capacity, varying between 40 and several hundred bytes. This is one of the rapidly changing characteristics of the technology, but under these memory capacity restrictions it was considered that XML is not currently an appropriate standard for data encoding.

For memory limitation reasons it was considered that a single byte tag, combined with a single byte length, is the best applicable solution. Suggestions for field repeatability were also made.

The proposal includes a set of tags, with the presumption that not all of these tags need to be defined up front with possible later additions. Tags for the following elements are anticipated:

- Inventory number;
- Current location;
- Home location;
- Date location change;
- Time location change;
- Userid location change;
- Insured value;
- Date insurance;
- Insurance policy number;

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43 This case study is based upon the content of the CIMI webiste (http://www.cimi.org), visited on 28/10/02 and 29/10/02.

44 http://www.cimi.org/public_docs/Smart_Label_Comment.html, date of original document: 16 October 2000, Revised: 27 February 2001

45 http://www.cimi.org/public_docs/Smart_Label_Comment.html

46 SPECTRUM, The UK Museum Documentation Standard'. 1997-2002. Brief presentation at www.mda.org.uk/spectrum.htm

- Insurance expiry date;
- Shipment request date;
- Shipment order number;
- Shipment date;
- Shipment time;
- Shipment agent code;
- Shipment userid;
- Arrival date;
- Arrival time;
- Photograph request date;
- Photograph order number;
- Photography due date;
- Photograph taken date;
- Photograph taken time;
- Photograph userid;
- Photograph technique;
- Photograph negative number.

Work on this standard proposal illustrates two of the problems faced by any organisation working on its own data structure. What are the basic principles? What content will be encoded? The latter had to be considered very carefully in order to meet the current demands for data interchange and data use. This work is often difficult in a field with such a rapid development. In particular, museums considering the application of RFID would have to decide whether they would like to adhere to this standard, or if they would prefer to define their own principles and data structures.

Scenarios

There now follows a collection of scenarios anticipating some of the ways in which RFID technology might be applied in a cultural heritage setting in the near future. It must be borne in mind that as the levels of production of smart tags and smart labels increase, the costs per unit will decrease significantly, bringing this technology within the reach of most organisations. The state of play in this area is well worth following with interest.

Scenario I – Museum

A museum is looking for an innovative way of making its collections more accessible and interesting to its patrons, and is also hoping to attract a broader cross-section of society to make better use of the cultural facilities that their taxes help to fund. The museum's director has read and heard about RFID technology, investigates its details, and decides to initiate a long-term implementation plan.

The most popular exhibits in the museum are digitised, and the digital representations stored in a central database. When visitors enter the museum they are offered a smart card to wear around their necks, and as they make their way through the collection they can press this card up against an RFID reader and register their interest in that object. Upon returning the card to the enquiries desk, the visitor may collect a printout of the digital versions of the objects he or she has 'collected' at the museum, as well as some in-

depth background information about them should she wish to pursue her learning further. Details of the objects that are of interest to particular demographic cross-sections can be collated in the database, or in a separate resource dedicated to storing and managing this information.

The smart card is cheap, durable and reusable, and on repeat visits the cardholder can receive suggestions about and directions towards previously unviewed objects that other visitors have 'collected', the assumption being that they may be of interest, too. The use of RFID technology thus enhances the learning process, and adds another layer of interaction and involvement to the museum experience overall.

The popularity of the new technology grows through word-of-mouth, and the museum is able to digitise an increasing number of its treasures, and link these with additional RFID readers. The museum may eventually allow patrons to keep their smart cards as souvenirs of their visit and to reuse them on subsequent visits. With the RFID technology already in place, the possibilities for extending the functionality and range of uses for the system are numerous. The readers attached to the exhibits may in time be linked to Web-based interactive devices, allowing the user to store and annotate thoughts on an item, as well as making these comments available to other interested visitors. The tags will also be compatible with portable devices, allowing for the possibility of personalised, 'nomadic' systems being introduced in the future.

Scenario II – Heritage Centre

A centre for the conservation of built heritage has a collection of some 50 historic buildings and, given a reasonable period of notice, can arrange guided tours in a number of European languages. After a demonstration of the benefits that smart tags can offer, the decision is made to improve these tours via the implementation of this emerging technology.

Upon entering the centre, each visitor is supplied with a pre-programmed tag, containing information on the preferred language. With headphones supplied, users may roam around the 50-acre site as they please, accessing information on the building features of the buildings by placing their smart tag close to one of the RFID readers discreetly situated around the site. The reader then determines the language in which its content should be presented, and instructs the audio-visual database system to relay tailored background information to the visitor's headset. This alleviates the need for the user to identify the object of interest and automates the interfacing side of the learning process significantly.

The new system has many benefits. The RFID system can be introduced in stages, with the most popular attractions and languages covered first. This will hold significant benefits for the centre's financial planners, as the spoken content only has to be captured once and may be reused many thousands of times. Resources are saved, as the management no longer has to employ bilingual tour guides and can accept group bookings at much shorter notice. Rather than being tied to a large group, visitors are free to follow their own paths through the site, and have a better chance of seeing what they want without the intimidating pressure of a sizeable crowd gathered around. Visitors become more evenly distributed around the site at any given time, easing the strain on staff resources. Visitor distribution has previously been a difficulty, particularly at the ends of the guided tours when large and potentially unmanageable groups traditionally descend on the tearoom and shop.

One potential risk of this approach is that users may feel a slight sense of isolation

while using their headphones and smart cards. The centre's staff must take time to ensure that the convenience offered by this new technology does not adversely affect the visitor's overall enjoyment of the experience.

Scenario III – Library

A library is looking for ways to offer better customer service and to improve its security system while keeping staff numbers at the same level. The library decides to use RFID tags, liking their anti-theft features and new principles of check-in and check-out.

Typical library processes where the technology can be applied are considered:

- Check in
- Check out
- Security (anti-theft)
- Inventory management, including assets management

For the initiation of the project the management of the library decides to cover the first three of these, with a view to incorporating inventory management in the future.

The library has to choose between a number of available systems. This process is easier now than in the past, as the library management can consult peers. The experience of other libraries shows that tagging of similarly sized collections can be achieved without a need for additional employees.

The library organises its new system as follows:

1. A sensor is located at the entrance/exit. It registers immediately any books which are not checked out. If an attempt is made to steal a book, the information system reports immediately details of the offending item, as the tags combine security bits with identification data.
2. A staff service station is placed at the lending desk. It is connected to the library database which is used for book check-outs and returns. This station is used by visitors of the library who are not yet familiar with the new system. In the long-term it will be considered whether this workplace should be used only for these purposes, or whether the staff member will have to take on additional duties. Such a staff service station is also extensively used when applying RFID tags to books.
3. There is also a self-check-out station for visitors who would prefer to use the new system. This consists of a computer terminal with a touchscreen and an RFID reader which can read the visitors' ID cards and check their books out. A facility to print receipts is also included.
4. Finally, the staff service station is used for the initial tagging.

The library management also have to decide on procedures for work in the new environment. For example, a procedure for placing RFID tag on a library book which already has a barcode might be organised as follows:

1. Put tag in tag programmer machine;
2. Read barcode label with scanner;
3. Verify correct barcode using the computer system;
4. Remove backing from tag and put tag in book;
5. Put cover label over tag.

The setting up of each stage of implementation may involve a significant amount of work, but several factors may ease this burden, including:

- There are people in a number of libraries who have the practical experience how to organise it;
- The tasks which have to be performed are routine, and easily described in formal procedures;
- Quality control and performance criteria can be formulated relatively easily.

For all these reasons, the library management considers that the benefits more than compensate the required effort.

Benefits and Risks

Summary

RFID technology holds the great promise for new ways for data circulation within organisations, in which one of the basic problems is the huge amount of data processing involved. The direct connection of the tags with their respective databases and the minimisation of the number of operations in routine processes will be beneficial. Additionally, as a technology which combines security with identification, it influences all procedures which previously required queries to a database and the subsequent extraction of information.

Complementary to these data processing benefits, the use of the technology contributes to the search for innovative services and studies, particularly in museums. The application of the technology goes beyond the use of smart labels merely for tracking items. The visitors are also supplied with such labels allowing management to study user behaviour and to support users in their museum tours. Such projects are still in their infancy and their benefits will only be realised completely in following years.

As a new technology, RFID brings considerable risks. For organisations with large numbers of visitors, a certain reported instability, such as erroneously read tags and false alarms, is not favourable.

There are also a number of problems which could arise from the immature standardisation in the field and future incompatibilities both of physical devices and data encoding and content. Since in the cultural heritage sector the data on collections are so huge, any risks of future incompatibilities are substantial.

Some types of tag have a limited life; the active tags which have built-in antennae are a good example of a class of short-life tags. Their longevity is completely acceptable for business applications, but not in the long-term run in cultural heritage organisations.

A specific problem related to RFID technology is the radio spectrum use. Radio frequencies are distributed and controlled by different bodies and sets of regulations in different countries, so agreement must be reached before the technology is fully transferable.

There are two respects in which RFID technology may bring both benefits and risks at the same time. The first of these relates to staff. The obvious risk is that staff jobs may

be cut due to the change in the amount of work to be done compared to current check-in and check-out practices. Benefits may include the fact that the staff will be able to offer better and more specialised service, to the visitors of the institution. Another difficult issue relates to privacy. In library applications, for example, the new means of self-check are considered very positive in this respect. On the other hand, in guided or studied museum tours this is can be a delicate matter, and must be handled as such.

Tabular Overview

Benefits	Risks
The technology combines identification and security	
Time is saved through the processing of multiple entries simultaneously	
Covers all information processes related to holdings circulation and to supply data for various purposes (e.g. for Internet publication)	
Brings innovative ways to organisation of tours in museums and other types of institution	
Leads to a change in the work processes structure (staff are able to perform direct services instead of checking in and out; also lowers the risk of repetitive strain injury.)	Leads to change in the work processes structure (possible staff reduction.)
	Radio spectrum problems: there may be different regulations in place in different countries, although the Conference of Post and Telecommunications Administrations (CEPT) now handles this in the EU
	Immature standardisation (especially on the tag content)
Privacy issues (self-check) are considered positive for the borrower	Privacy issues: museums tracking visitors might be considered a negative
	Potential incompatibility of tags/devices in the future
	Estimation of lifespan for some types of tags: 10 years for commercial purposes (in the cases of active tags this is due to battery life) is OK, but not sufficient for cultural heritage institutions
	High reported number of cases of erroneously read tags (reported 1% in real-life cases) due to problems with tags or readers

Introducing the Technology

Policy and Organisational Framework

The current library applications of RFID technology can be put into practice by following clearly structured procedures. The process of tagging collection does not require extensive training and is usually done successfully by the library staff. The standard work procedures are facilitated after the implementation of RFID. Tensions due to expectation of staff cuts are preventable.

The museum applications, while on the innovative side, are not so predictable. They lie more on the border of current research and application of new technologies in experimental ways. The estimation of unexpected outcomes can be more problematic.

Existing Infrastructures Required

The technological infrastructure in the organisation definitely changes with the implementation of RFID technology. This influences both hardware equipment such as gate sensors, staff stations, check-out stations, tag printers and specialised wands and the installation of new software.

What organisational structures make the technology appropriate?

The use of RFID technology does not influence the organisational structure. Usually a core committee for the RFID implementation is set up, and all organisational staff responsible for the collection management are likely to be involved in the project work.

A checklist of typical issues which will need to be discussed will include:

- Is preliminary planning covering all anticipated organisational processes, or just a subset to start with?
- What are the performance criteria for the 'ideal' system?
- Is the project plan realistic compared to the experience of other organisations?
- Is simultaneous use with barcodes envisioned?
- What are the needs with regards to staff training? Will the provider train the staff properly?
- What is the most adequate way to introduce the technology to the visitors (users)?

Staffing levels and user base issues

Real-life experiences reported so far show that there is no need to introduce additional staff members. The future problem of reallocating some of the staff to other tasks should be carefully considered.

Compared to other innovative technologies, this does not imply challenges to the user in the sense that it covers traditional procedures which are normally known to the visitors of the organisation. The mixed policy of having both self-check stations and staff

service stations in the libraries, for example, makes the introduction of the new technology very easy for visitors because they still have the traditional, personal support.

Appendices

Appendix I – Comparison table

The following table contains a list of features which may be used to compare different offers.

FEATURE	POSSIBLE VALUES
Flexibility of data formats	y/n
Is there experience with application of the technology in similar institutions?	y/n
What data formats are supported?	(fixed, programmable)
Is security info included?	y/n
Is anti-collision supported?	y/n
Could the tags be used on metal surfaces?	y/n
Tag memory capacity	Number of bytes
Tag functionality	Read only or Read and Write
With which standards is the solution compatible?	Vary according to the supplier
Costs tags hardware software	Vary according to the supplier
What readers can be used for the tags?	only those of the same supplier, or more
Interoperability between different types of tags	possible/impossible
Physical attributes size possibility of encapsulate the tag usage on metal surface	Vary according to the supplier

Appendix II – Suppliers and developers

The following table gives a general idea about the most active technology providers and compares key characteristics of their products.

Company name	Tag name	Tag type	Memory (bits)	R/W	Frequency	Anti-theft bit	Read range (cm)	Read-speed (items/sec)	Multi-read (labels/sec)	Price ($)	URL
3M Library Systems	–	Tag-it	256	R/W	13.56 MHz	n.a.	–	2	-	1	www.3m.com/library
Alien Technology	NanoBlock	Proprietary (passive)	64	R/W	915 MHz	n.a.	5	-	200	n.a.	www.alientechnology.com
Checkpoint Systems	Performa	MicroChip	1024	WORM	13.56 MHz	no	–	20	–	1	www.checkpointsystems.com
Copytag	MCRF45x	MicroChip	154	R/W	13.56 MHz	–	100	–	Multi-read	0,78	www.copytag.com
Helicon	Talking tag	I-code	44 bits	R/W		–	–	–	–	n.a.	www.helicon-cs.com
Hitachi	Mu-chip	Passive	128	ROM	2.45 GHz	–	–	–	n.a.	n.a.	www.hitachi.com
Intermec	Intellitag 500	Proprietary (passive)	–	R/W	915/2450 MHz	– –	– –	– –	–	n.a.	www.intermec.com
Intellident	1. Folio 20 2. RI101-112	Tagsys Tag-it	128 64+2K	R/W R/W	13.56 MHz 13.56 MHz	yes –-	70 –	– –	Multi-read 50	n.a. n.a.	www.inetellident.co.uk/Home
Infineon Technologies	My-d	Proprietary (passive)	10K	R/W	13.56 MHz	–	70	–	Multi-read	0,3	www.infineon.com
Lucatron	FLR-101	I-code	512	R/W	13.56 MHz	–	120	–	–	n.a.	www.lucatron.com
Omron	V720	I-code	512	R/W	13.56 MHz	–	–	–	–	n.a.	www.omron.com
Philips	1. I.Code 2. HSL	I-code I-code	512	R/W R/W	13.56 MHz 2.45 GHz	yes –	– 350-700	– –	30 Multi-read	n.a. n.a.	www.philips.com

Company name	Tag name	Tag type	Memory (bits)	R/W	Frequency	Anti-theft bit	Read range (cm)	Read-speed (items/sec)	Multi-read (labels/sec)	Price ($)	URL
Siemens	MOBY-E	Proprietary (passive)	8K	R/W	13.56 MHz	–	– –-	– –	– –	0,1	www.siemens.com
Tagsys	C220 Ario	Tagsys Tagsys	128 2K	R/W R/W	13.56 MHz 13.56 MHz	yes –	100 15-30	– –	Multi-read Multi-read	n.a. n.a.	www.tagsys.net
Tech Logic	–	Tagsys	128	R/W	13.56 MHz	yes	100	–	Multi-read	n.a.	www.tech-logic.com
Texas Instruments	Tag-it	Tag-it	64 +2K		13.56 MHz	–	–	–	50	n.a.	www.texas-instruments.com
Vernon	Folio 20	Tagsys	128	R/W		yes	100	–	20	n.a.	www.vernlib.com
VTLS	Tagsys	Tagsys	74	R/W		yes	–	20	–	1	www.vtls.com
X-IDENT	TTP-CD TTF-Label TDP-Paper	i-Code Tag-it i-Code	64+384 32+256 64+384	R/W R/W R/W	13.56 MHz 13.56 MHz 13.56 MHz	– – –	80 100 150	– – –	30 50 30	n.a. n.a. n.a.	www.x-ident.com

Virtual Reality and Display Technologies

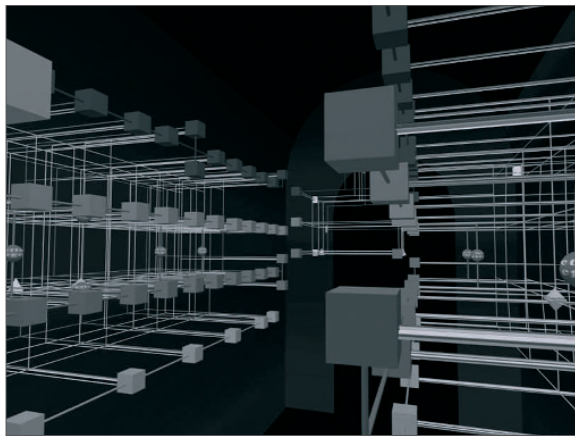
Executive Summary

Virtual Reality (VR) technology has already been used to great effect in certain heritage areas, most notably and most successfully in theatre studies and archaeological reconstructions of non-standing or partially standing structures and buildings. Given its enormous potential as a training aid, Virtual Reality Modelling Language (VRML) has also been widely-used in other, more physically dangerous sectors, such as engineering and the military, for a number of years. It has revolutionised working practices of architects and designers. Optimism is high for the future of VR and other three-dimensional (3D) technologies in cultural and other sectors. Further adventurous applications of VR technology are envisioned for future use in institutions such as museums and visitor centres, as well as in innovative and adventurous performance pieces.

The uses of VR and other 3D technologies have traditionally been constrained by the great demands they are likely to place on computer hardware and memory. As processor speeds increase and the cost of memory falls, the possible results will become ever more impressive, immersive, interactive and involving. It is also anticipated that high-quality, high-specification, Web-based VR will be with us sooner rather than later, bringing accomplished 3D into the home as well as the institution.

This report focuses primarily on VR technology, treating it as representative of 3D technologies in general, since much of what is said of VR in terms of benefits and drawbacks can often be applied to these other technologies with co-equal validity. Other technologies such as *QuickTime Virtual Reality* (QTVR), *Rich Media 3D* (RM3D) and the new Extensible 3D language (X3D) are also covered, with the specific benefits and drawbacks of individual technologies and techniques outlined and examined in the appropriate sections.

Featured heritage case studies in this Section include the **European Commission's** THEATRON project, **Italy's** Consiglio Nazionale delle Ricerche, and the **Greek** ARCHEOGUIDE initiative.



© Consiglio Nazionale delle Ricerche, Italy

Introduction to Virtual Reality & Display Technologies

Background

According to Donald Sanders, President of **Learning Sites Inc**, 1998, the ideal Virtual Reality (VR) environment is 'an interactive, self-directed, multisensory, computer-generated experience which gives the illusion of participating in a synthetic three-dimensional environment.'[47] As anyone with even a casual acquaintance with VR will know, these are a set of ideal goals rather than a checklist to determine what is and what is not a Virtual Reality system. VR developers are making steady progress towards the realisation of this goal.

For a considerable time, humankind has been attempting to convince itself that it is somewhere else, partaking in some alternative world. Despite what Sanders may write in hope, 'illusion' is not a necessary and essential attribute of a successful or useful VR system. In VR teaching applications, for example, the accuracy of the virtual environment is of secondary importance to the material being taught, and such a system will stand or fall on its eventual results rather than on its realism. The benefits and risks of VR and education are examined in depth below.

As well as the educational sector, VR has been used to the best effect in archaeology and theatre studies. Each of these is eminently suitable to the capabilities of VR, and was particularly so in the pre-Internet days when standalone applications were the form that most VR projects took. As Web-distributed VR has progressed alongside the expansion and broadening of the Internet, other applications for 3D technology including multi-participant performance, interactive television and real-time virtual exploration have come to the forefront of contemporary cultural heritage research.

Overview – VR systems and languages

A number of wildly varying languages and techniques exist which can be gathered under the umbrella term of 'Virtual Reality'. These stretch from pure programming environments such as *Java3D*, through coding environments such as the HTML-like Virtual Reality Modelling Language to photographic techniques such as those employed by **Apple's** *QuickTime Virtual Reality* (QTVR).

Each has its own strengths and weaknesses. The primary decision that needs to be taken when implementing a VR solution in an organisation is determining precisely which system fits the predetermined objectives most closely. The various suitabilities of each technology are outlined below.

Where is VR technology currently used?

Movie and video games companies tend to lead the way in the development of this technology, and there will be an intentional and necessary overlap between this briefing

47 http://www.cssjournal.com/sanders.html

and that on Games Technology[48], below. The creators of VR-type computer games are understandably cautious about sharing too many of their developmental secrets, but a comparison between games such as **Microsoft's** *Flight Sim 2002* and the leading cultural practitioners of VR demonstrates clearly the debt that standardised VR development owes to the more overtly financially-motivated world of mass-market entertainment.

Another traditional and popular use of VR technologies is in the field of design. Architects and engineers use Computer Aided Design (CAD) programs in conjunction with VR to produce interactive, explorable and, in the case of objects, manipulable models of their designs. This aids designers in assessing the practicability of their creations and, in the case of architecture, facilitates a greater understanding of what a building will be like to experience once built. The introduction of these technologies has led to nothing short of a revolution in working practices for architects, engineers and designers.

How 3D Technologies Work

Dedicated browsers and viewers

Before outlining the specifics of particular 3D technologies, we wish to lay stress on one of the prerequisites of VR explorations and authoring. Just as a Web browser is required to parse and interpret HTML files, a dedicated viewer/browser is almost always needed to view and explore virtual worlds. Such products include **Computer Associates'** *CosmoPlayer*, **Sony's** *Community Place*, **Intervista's** *WorldView2*, **Parallel Graphics'** *Cortona VRML client*, and **SIM's** *VRMLView*. QTVR requires *QuickTime* to be downloaded from **Apple's** Website to the user's machine before panoramas can be viewed. This needs to be done only once, and after the download the software continues to reside on the user's machine for future use.

A note on standardisation

Standards on VR and other 3D technologies have often failed to inspire developers into persevering with them, with the result that there is currently no single VR technology that can be considered the 'industry standard' for any business sector. Thanks to the efforts of some organisations this is beginning to change.

The **Web3D Consortium** has recently broadened its scope from VRML only to include a variety of Web-based 3D technologies to be considered for standardisation. The goal of the new Web3D charter is to create a suite of interoperating standards which will be targeted at specific industries and market sectors.

The **World Wide Web Consortium** (W3C) is a non-profit, vendor-neutral industry consortium organisation charged with the development of common protocols for the evolution of the Web. The Consortium's work programmes cover a variety of user inter-

48 The reader is invited to see the section on Games Technology.

face and standardisation issues, including HTML, 3D graphics and wider issues of access and internationalisation.

Virtual Reality Modelling Language (VRML)

The language

The acronym VRML is slightly misleading: VRML is not a language as such, rather it is a *file format* for describing interactive 3D objects and worlds and is used by WWW users for viewing 3D scenes just as HTML is used to view text. The intention of VRML authors was that it should become the standard for interactive 3D simulation within the Web.[49] As with HTML, VRML files are *parsed* by a dedicated browser, such as **Cosmo's** *CosmoPlayer*, or *Cortona* by **Parallel Graphics**.

VRML is a collection of about 60 different *nodes*, which are ways of defining pre-defined or user-defined shapes. The five VRML *primitives*, the fundamental shapes, i.e. sphere, box, cone, cylinder and text, are defined in only a small amount of code, and can be easily modified, with a cube becoming an oblong, a sphere being transformed to become an egg, and so on. Textures and appearances can then be 'mapped' to these shapes. Coders can decide which sides of a 3D block need to be rendered and which may be safely ignored, for example the underside of an individual floor tile which is unlikely to be seen in any view, thereby saving precious processing time. Decisions can also be taken on whether every polygon is rendered individually or as part of a group. Virtual reality is a relatively processor-intensive business. The optimisation of code remains a necessity so that the virtual world will appear and behave as closely as possible to the real world. As processor speeds increase, less emphasis has been placed on the processing power needed to render VR worlds quickly, and the focus has moved to bandwidth. A broadband user will be better placed to view large Web-distributed VRML files and potentially interact with them in real time than a user with access only to a 56 kbps modem. VRML data may be stored in and retrieved from a bi-directional database, thus further reducing the sizes of files and speeding the rendering of large virtual worlds.

Events and behaviours play a central role in creating realistic and illusory effects.[50] Polygons can be animated, and be made to move either independently or as a result of user input/interaction. Objects may have *behaviours*. In terms of realism, for example, users will ideally want most objects in a virtual world to be solid so that they are not able to walk through walls or fall through floors. Conversely, with some objects, such as smoke and water, the user should be able to pass through with little or no resistance and these choices add another level of complexity to the coder's role. Ambient sounds such as rain or animal calls and event sounds like a key scraping in a lock, for instance, can be added to VRML worlds while intelligent lighting effects may be employed to add further authenticity to the experience overall. As any climber will reveal, a hillside in the rain and a hillside in bright sunshine can seem like two altogether different places, and the attentive use of weather and lighting effects in a virtual world will hold the user's attention longer than a single unchanging perspective. Using events with care, a fourth dimension, time, may be applied to VRML worlds, and VR in general has the potential

49 See http://cic.cstb.fr/ILC/ecprojec/vega/Demo/white_paper.html#FOOTNOTE_2 for a fuller analysis.
50 The VRML event handling language VRMLScript is a subset of JavaScript, and Microsoft's VBScript is also compatible with VRML.

to simulate the passing of a day, a year, a millennium. Sounds and behaviours can be integrated, so that walking over leaves sounds noticeably different to walking across a lawn, for example, although this will have implications on the sizes of the source files. Multimedia links with external material are something with which VRML currently struggles, though these are bound to be a development of the future.

Viewpoint definitions may be used to give the users a rapid contextual sense of where they are in the world, and will save time and memory if only a brief overview of the objects or world is required. In addition to this, virtual fly-through routes may be defined to highlight aspects of the world to non-active viewers. The usefulness of these will inevitably depend on the necessity of participation in the world/experience.

One of the most useful current developments in a cultural heritage context is in the work being done on 'avatars' and user profiling. *Avatars* are virtual representations of human or computer-generated participants in virtual worlds. Technically, avatars are cylindrical in VRML, though they may appear to be human-shaped. This cuts down on the length of multi-user VRML files (cylinders being primitives) but also disallows, for example, shaking hands or many other human interactions. User profiles can be stored in a database to allow for repeat visits and the development of relationships both inside and outside the virtual world. An interesting example of this is the Finnish multi-user world, *Conversations With Angels*, which permits multiple online users to interact and chat in real time using **blaxxun's** *Contact* VR browser.[51]

Development environments

The simplest way of developing a VRML world is by hand-coding it through a basic text editor such as **Microsoft's** freely available *WordPad*, although any text editor would suffice for this. Hand-coding has the advantage of being highly accurate and efficient, but the disadvantage of being very complicated and time-consuming. The next step up from this is a dedicated VRML editor, such as *VrmlPad* by **Parallel Graphics**, which assists in the coding process in the same way as a program like **SoftQuad's** *XMetal* facilitates the creation and editing of XML files with layout guides and debugging features. At the top of the VRML design chain sits I*nternet Space Builder* by **Parallel Graphics**, a WYSIWYG (What You See Is What You Get) interface which, like *Dreamweaver*, creates less efficient code and is relatively inexpensive at around €80 per licence, significantly less than it has cost previously. A similar package is *Cosmo Worlds* which generates code that is often difficult to modify by hand. There are a number of applications created to optimise such auto-created VRML code, including **TriVista's** *VRML DataTrimmer*, **Radialsoft's** *VRML Opt, vwaif* (freeware, open-source), *Shrinker* (freeware, open-source), and **Trapezium Software's** *Chisel*. **Trapezium** also produces *Vorlon*, which checks that code meets VRML specifications and standards.

Essentially, as with many other heritage technologies, a trade-off will be required between the cost and the usability of the development environment. Given the ease of use and speed to learn, a visual environment will usually be preferable to hand coding, but this comes at a price both fiscal and computational.

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51 Research into automatically populating virtual worlds with thousands of avatars is currently being carried out at University College London. Details can be found at http://www.cs.ucl.ac.uk/research/vr/Projects/Crowds/index.html. Conversations With Angels is hosted at http://angels.kiasma.fng.fi/

Difficulties with VRML

Unlike HTML, the language with which it is most frequently compared, VRML is not easy to learn, and its syntax is certainly not so flexible or intuitive. Even with prior experience in other programming languages or environments, a significant amount of dedicated study and practice would be necessary for an organisation's staff to be able to construct its own realistic virtual worlds. As outlined previously, visual development environments are easier to use, but often produce less efficient code and can be expensive.

Bandwidth restrictions are the factor most likely to hamper the deployment of VRML across the Web. Broadband access remains rare in the home, and in order for VRML worlds to be as realistic and explorable as possible, the source files must necessarily be large. On slower computers, rendering time may be a problem, particularly in ensuring that users do not reach parts of the world that the processor has not had time to render. This problem is compounded when images are photomapped onto the surfaces. Conversely, reduction of file sizes and polygon count can cause distortion and a loss of believability, thus detracting from the initial aims of virtual reality.

Extensible 3D (X3D)

Little tangible progression seems to have been made with VRML since 1997, apart from the slow genesis of X3D, which is the **Web 3D Consortium's** next-generation, backwardly-compatible successor to VRML. Its mission is 'to bring rich and compelling 3D graphics to the Web.'[52]

The format is intended not only for storing and displaying 3D graphics but also as a middle ground between different graphics programs, allowing them to exchange files between them. Essentially, X3D will hold the same benefits for VRML users as XML has for HTML professionals, ensuring that files are properly structured and easily transferable.

Like VRML, X3D has its own dedicated development environments. The **Web 3D Consortium** has developed its own *X3D-Edit Authoring Tool*[53], and Xj3D *Java Implementation* is also currently in development.[54]

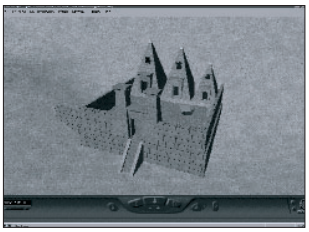
QuickTime Virtual Reality (QTVR)

QTVR is not a virtual reality technique, nor does it render images in three dimensions. It is, however, significant in any serious discussion of contemporary VR, particularly given the quandaries surrounding contextualisation and where to draw the line. In **Melissa Terras's** VRML model of *Sen-nedjem*[55], the tomb is not actually in isolation, but it proved to be too computationally intensive to render even static models of the other tombs. A reasonable solution was to surround the VR model with a static photorealistic

52 From http://www.web3d.org/x3d.html
53 See http://www.web3d.org/TaskGroups/x3d/translation/X3D-EditAuthoringTool_files/frame.html for details.
54 See http://www.web3d.org/TaskGroups/source/xj3d.html
55 Internet Archaeology, http://intarch.ac.uk/journal/issue7. Melissa Terras completed this project at HATII (University of Glasgow) in conjunction with the Kelvingrove Museum and Art Gallery.

rendering of the original surrounding buildings and/or features. Attractive QTVR 'cyber-montages' can be constructed using packages such as **Adobe's** *Photoshop*[56] in conjunction with **Apple's** proprietary software.[57]

From Melissa Terras: A Virtual Tomb for Kelvingrove



From Melissa Terras: A Virtual Tomb for Kelvingrove

Since the user is limited to what is captured on camera, these areas are not truly explorable, but the photographic approach dramatically improves the prospects of user immersion in the virtual world, one of the main aims of VR, and adds a sense of context and realism to the experience as a whole. *QuickTime* has other potential applications. QTVR scenes are a collection of one or more QTVR panoramas and/or object movies which may be linked together via hyperlink-like 'hot-spots', allowing users to navigate from one panorama to another as they negotiate the scene, pausing where they please to examine and, to an extent, 'manipulate' object movies of relevant artefacts. This gives the beginnings of the illusion of 'travelling', albeit instantaneously, between separate buildings.

While QTVR panoramas are represented by a 360-degree view from a single point in space, it is also possible to create QTVR Object Movies, which show single objects captured from a variety of angles. This process is analogous to animation. Only the captured stages of a motion can be shown, and the more realistic the manipulation of the object, the more pictures are required to represent it and, hence, the larger the file becomes. As with VRML, a balance must be struck between realism and technical constraints.

Rich Media (RM3D)

Rich Media is defined as being 'content that leverages dynamic graphics, animation, and/or audio/video (A/V) to be compelling and entertaining,' although *interactivity* may soon be added to these prerequisites. According to its Website (http://groups.yahoo.com/group/rm3d), the Rich Media Working Group is 'organized by the **Web3D Consortium** to develop a standard to describe multimedia content in the context of a 3D presentation engine.' Their ultimate goal is 'both to inform and be interoperable with other standards in this space, such as *VRML200x* and *MPEG-4*.

The *RM3D* specification remains very much a work in progress, and is being developed by a broad range of companies, including **3Dlabs, ATI, Eyematic, OpenWorlds, Out of the Blue Design, Shout Interactive, Sony** and **uma**.

If considered as another media element along with digital images and sound, 3D graphics hold the potential to include explorable, manipulable and transformable objects in multimedia applications. Interactivity is an inherent part of most VR systems, with the

56 See for example http://www.taosnet.com/architectVRe/html/DerachoQTVRPanorama.html

57 The licence costs in the region of €500. Donald Sanders's company, Leaning Sites Inc (www.learningsites.com), specialises in this type of approach.

partial exception of QTVR. As hardware capable of handling advanced 3D graphics becomes the norm in home PC's and other consumer durables such as digital television, a platform for rich media will aid significantly the progress of the interfacing of virtual reality and multimedia content, something with which traditional approaches such as VRML have struggled.

One of the chief benefits of *RM3D* is that the content may be represented as graphics, using video only where necessary for the underlying content. This enables the delivery of 'rich' content without the heavy bandwidth requirements that can often cause Web-delivered VRML and other techniques to falter. *RM3D* content will be compatible with a variety of platforms, from hi-spec mobile devices to computer gaming consoles and digital TV boxes, as well standard Web browsers. Some of the existing players that provide an early glimpse of the capabilities of rich media presentation include **Eyematic's** *Shout 3D*, **OpenWorlds'** *Horizon* and **Sony's** *Blendo*.

Java3D

Java3D differs from the above technologies in that it is an Application Programmer Interface (API) rather than a language in its own right like VRML or a photographic technique like QTVR. Its semantics are close to those of VRML, but unlike VRML, which can be learnt and executed by non-programmers, programmes must be already be fluent in Java in order to utilise *Java3D*.

Due to its power and complexity, *Java3D* is primarily useful for standalone applications, such as interactives in museums, and is not really suitable for Web delivery. External skills may have to be brought in if an organisation wishes to employ this technology, although it is more likely that such work would be outsourced to a dedicated expert, thus depriving the organisation of the ability to update or extend a costly *Java3D* interactive in-house. Much planning and consideration must be given to such an investment of time and resources.

OpenGL (Open Graphics Library)

Another API, *OpenGL* is the foremost established environment for developing portable, interactive 2D and 3D graphics applications. Since its introduction in 1992, *OpenGL* has become the industry's most widely used and supported 2D and 3D graphics application programming interface (API), bringing thousands of applications to a wide variety of computer platforms. *OpenGL* incorporates a broad palette of rendering, texture mapping, special effects, and other powerful visualisation functions. Developers can make use of the impressive power of *OpenGL* across all popular desktop and workstation platforms. This platform-independence may come at a cost. As an API, *OpenGL* requires dedicated hardware and software to run, and often modification will have to be made to existing hardware such as PC graphics cards. As with *Java3D*, external expertise may have to be sought.

VR Technologies and the Heritage Sector

Brief background

When used effectively, VR and other 3D technologies reduce the necessary, artificial distances between users and artefacts. The potential for manipulation of virtual objects and the exploration of no longer standing buildings and altered landscapes adds much to the learning venture, both in terms of educational use and of user enjoyment. Although still comparatively primitive, head-mounted display equipment in virtual exploration and learning will assist in the move towards the eventual goal of total immersion and participation.[58]

Despite the possibilities for persuasion and immersion, it may occasionally be preferable to draw attention to the artificial nature of the VR venture. The *ARCHEOGUIDE* project combines VR-type reconstructions (such as that of the Temple of Hera[59]) with QuickTime-style photorealistic backgrounds. This provides improved contextualisation over stand-alone VRML, while at the same time drawing the user's attention to the artificiality of the venture via the juxtaposition of the reconstructed model with digitised photographs of its present-day surroundings. The name for this technique is 'augmented reality'. The *ARCHEOGUIDE* team is also involved in developing new tools for improved organisation and storage of cultural heritage information.

The most exciting and innovative applications of VR in today's cultural heritage sector are in the performing arts. Interactive performance pieces such as *Avatar Farm* and **Blast Theory's** *Desert Rain*[60] are testing the boundaries of participation and performance. maria x, a student at Goldsmith's College, London, has recently begun her doctoral thesis on the theoretical implications of VR and cyberspace in performance and her work in this area may have significant impact on the different and evolving ways in which we consider the relationships between actors, participants, audiences and technology.[61]

The following case studies present a picture of the current uses of VR and other 3D technologies in the cultural heritage sector today, including VRML, QTVR, and Augmented Reality (AR) techniques, as well as addressing some of the theoretical issues raised from the use of VR in performance. The case studies are followed by scenarios which extrapolate future potential uses of these technologies in a range of types and sizes of organisation.

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58 Please see the section on Human Interface Issues, for more coverage of fully immersive interfaces, including CAVEs and Power Walls.
59 http://archeoguide.intranet.gr/papers/hera_Movie.mpeg
60 http://www.blasttheory.co.uk
61 As the thesis itself is a kind of performance, maria x's progress can be followed at http://www.cybertheater.org

Case Studies

Case Study I – THEATRON (www.theatron.org)[62]

Based principally at the University of Warwick, THEATRON, an acronym for *Theatre History in Europe: Architectural and Textual Resources Online*, is an award-winning[63] European Commission part-funded project which engages in the virtual reconstruction of famous and historically significant theatres. The project was developed over a three-year period with a budget of €1.6M, half of which came from the European Union, and half of which was raised by the project partners.

Between the directors at the University of Warwick and the partner organisations across Europe, the following plan was devised and followed:

1. To identify and target the theatres that would be modelled
2. To gather architectural and other background details on these theatres
3. To model the theatres in *3D Studio Max*
4. To map textures to the models via comprehensive rendering
5. To transform the architectural CAD models into VRML
6. To implement an attractive and intuitive interface for the finished product

The first and second steps were carried out by the heritage experts at the university, with the initial 3D modelling performed by the German architectural firm **Atelier 4D**. These *3D Studio Max* files were too large in size for real-time rendering, so they were converted into smaller, optimised VRML files by Drew Baker, a VRML expert at Warwick. The interfacing and final software design and coding was carried out by another partner organisation, **Aebly**. One word of advice that THEATRON Project Co-ordinator and Academic co-Director, Professor Richard Beacham, offered was the importance of a dedicated technical project manager when embarking on a venture of this scale, with numerous partner organisations spread across the continent. Given the sequential nature of the work, it was necessary to time each phase accurately and to plan the timeframe realistically.

THEATRON endorses *CosmoPlayer* for use as its standard VRML browser, though other browsers such as *Cortona* work equally well. Other VRML interfaces may be considered for the future if the THEATRON project is developed further, among them the revolutionary *Quake* gaming system, which would involve the project partners teaming up with games technology developers to maximise the usability ('playability' in games terms) of the interface. Other proposed developments include the capacity for multiple avatars which would be viewable in real-time by other participants and spectators, thus leading to increased enjoyment, immersion and interactivity.

Among the benefits to the learning process is the inclusion of links to digitised photographs, audio and other rich media resources such as QTVR panoramas, as well as an online glossary intended to assist students in their self-directed learning. Links to relevant external sites are included as well. Given the flexibility of the software, it may be adapted externally to meet a varied range of VR purposes, particularly when it comes to teaching.

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62 This case study is based on a telephone interview with Professor Richard Beacham, THEATRON Project Co-ordinator and Academic co-Director, and member of the School of Theatre Studies at the University of Warwick, England. The interview took place on 28/11/2002

63 See the 2002 Computer World Honors Program for more details: http://www.cwheroes.org/his_4a_detail.asp?id=412

The pedagogical benefits of THEATRON are strong, allowing theatre and classics students alike to experience the differences in acoustics that would be perceived by spectators during a performance, as well as giving a representation of the 'sightlines' that actors and audience would have enjoyed. In fact, the educational benefits of the project have exceeded expectations, and it has been very popular among students in a number of different countries. The application is distributed across the student network at the University of Warwick, and students from a variety of disciplines have accessed and explored it successfully.

THEATRON is an excellent example of a project that manages to integrate technology, education, preservation and entertainment while remaining profitable at the same time. Site copies have been sold to organisations in Australia, Israel and the US, and annual subscriptions continue to be sold every day.

Case Study II – Blast Theory (www.blasttheory.co.uk)[64]

Blast Theory's groundbreaking *Desert Rain* is an amalgamation of performance, game, virtual reality and political polemic. The piece takes the variance of different accounts of the first Gulf War (military, media, political) as a starting point, and addresses issues of perception and deception via innovative applications of virtual reality and other related technologies.[65]

Desert Rain is a collaborative effort between a number of specialist parties including the European Commission's *eRENA* project, the University of Nottingham's *Mixed Reality Laboratory* (MRL) and the *ZKM Center for Art and Media*[66]. It was approximately three years in development, premiering in Nottingham in 1999. The project had an initial budget of €167,000, plus the additional expertise and time of the technical personnel and the artists themselves, which is estimated to have been worth a further €80,000.

A team of five at the MRL, most often Professor Steve Benford, worked together with the artists at various times and stages of development, and some of the more technical projection and display work was carried out with material assistance from **AGFA** and **Sony**. The real-time interaction between real-world and virtual elements was perhaps the most difficult and time-consuming element of the performance and, as an untried technique, much of this work consisted of trial and error, and finding the optimum position for the different pieces of equipment. The VR system employed was the MRL's own virtual conferencing software, *MASSIVE v2.0*, a stable and mature system with which the technical team were already familiar. A couple of changes were made over the course of development in order to allow collision detection and terrain following, each of which was felt to be essential in meeting the group's aims for multiple simultaneous avatars. One member of the MRL continues to tour with the group in order to handle potential technical difficulties.

Virtual reality is only one of the many aspects of *Desert Rain*. Other technologies employed include magnetic swipe cards, back-projection onto a rain curtain and purpose-built wooden platforms which act as the motion interface between the real and

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64 The following material is based on an interview with Matt Adams of the Blast Theory group of artists, and on information from the group's Website and that of the University of Nottingham's Communications Research Group. The interview was conducted via telephone on 09/01/2003.

65 A fuller description of the piece can be found online at http://www.blasttheory.co.uk/work_desertrain_desc.html

66 http://www.erena.kth.se/; http://www.crg.cs.nott.ac.uk; http://on1.zkm.de/zkm/

virtual worlds, with the participant's body weight being used to control avatar movement in four directions. This approach allowed the artists to focus attention on the performance element, rather than the performance becoming a background for the technology.

Despite early fears that its requirements may have been a little over ambitious, *Desert Rain* has, with upwards of 10,000 participants to date, become the most successful and longest running project in **Blast Theory's** history. Performances continued through late 2002 (Sydney) and early 2003 (Madrid). Substantial evaluation has been carried out on the project, with ethnographer Dirk Vom Lehn of King's College London conducting research on the actions and interactions of a number of participants. A book of theoretical essays on the implications of the work has been published, with contributions from Matt Adams of **Blast Theory** and Professor Benford, among others.[67] A paper on *Desert Rain*, 'Orchestrating a Mixed Reality Performance', was also presented at the Computer Human Interface conference in 2001.[68]

Case Study III – Consiglio Nazionale delle Ricerche (www.cnr.it)[69]

Founded in 1923, the Consiglio Nazionale delle Ricerche (CNR) is Italy's national scientific research centre, with a primary function 'to carry on advanced basic and applied research, both to develop and maintain its own scientific competitiveness, and to be ready to effectively and timely take part in the strategic fields defined by the national planning system.'

One of the areas in which the CNR is heavily involved is that of virtual reality and its implications for the heritage sector. Maurizio Forte is a member of an institute whose current scientific activities are oriented towards Desktop Virtual Reality (DVR) applications, particularly the creation of DVR projects and systems based on *OpenGL* environments. These kinds of projects generally involve the reconstruction of sites/monuments/structures or archaeological landscapes using *OpenGL* technologies and the C++ programming language.

© Consiglio Nazionale delle Ricerche

Devices to demonstrate the dimensions and scale of the Scrovegni's Chapel model

For Forte, real-time DVR applications which integrate the power of a full 3D interface with a complex information system can open up new perspectives for archaeological communication and interpretation in terms of quality of information, cognitivity and geometry of information, both for the scientific community and for end-users.

In the case of the recent *Scrovegni's Chapel* project[70], the CNR team was composed of three persons for the photogrammetry, two for the architectural models, two for the computer graphic and image processing, one for C++ programming, two composers and experts in ancient music, four for translations, two for technical-logistic direction, two for multimedia, four for the texts, and one for design, interface and general direction. As is normal in this type of project, there was also a scientific committee for handling general

67 An eRENA report on Desert Rain, titled 'Pushing Mixed Reality Boundaries', can also be found online at http://www.nada.kth.se/erena/pdf/D7b_1.pdf

68 Available online at http://www.equator.ac.uk/projects/citywide/documents/desert-rain-paper.pdf

69 This case study is based on an email questionnaire completed by Maurizio Forte, Senior Scientist at the CNR. Subsequent background information has been gleaned from the CNR's Website.

70 http://www.mlib.cnr.it/vhn/SitoScrovegni/apertura.htm

supervisory duties. The team spent a substantial amount of time at the outset of the project giving a general VR overview to non-technical people, including cultural managers, museum directors, and municipalities. In this 'brain storming' period the strategies and plans were decided upon collaboratively using concrete examples and prototypes, all in accordance with the final cultural aims.

The most time-consuming sections of the project were the photogrammetric work, the virtual behaviours/inclusive interactions, and the C++ software programming[71]. In terms of a general budget, the cost percentages were roughly as follows:

- Virtual Project and management – 10%
- Spatial data-entry – 15%
- Graphic interfaces – 15%
- Multimedia links and effects – 10%
- OpenGL Programming (C++) – 30%
- Music and sounds – 3%
- 3D modelling and OpenGL optimisations – 14%
- Texts – 3%

In the Scrovegni's Chapel project, the user interface consists of a virtual inclusive environment within which the user is always free to move in three-dimensions, and where he can interact with more than 500 behaviours. As Forte points out, the first 'historic' phase of VR development was essentially visual, but now the use of inclusive behaviours and, in the near future, VR artificial intelligences is radically changing the process of virtual learning and the perceptive impact that it holds.

The CNR has undertaken two main directions of research based on *OpenGL* technologies: virtual landscapes and virtual intra-sites, including monuments, single sites, and structures. The results have been encouraging. With DVR, they can change the perspectives of the research and of the communication of cultural data, as well as in the educational or scientific fields. Another, more tangible benefit of DVR is that the software runs well on low-cost PC's using *OpenGL* graphic cards, and it has recently been made available for use on Notebooks supporting the same type of cards.

The team at the CNR has tested two main interface solutions for different projects: the Virtual Theatre at the CINECA in Bologna, and *Visionstations* which have been used in conjunction with the company **Elumens**. The Virtual Theatre consists of a wide stereo hemispheric screen together with 3D surround sound. In this environment the experience of visualisation is collective, even if there is only one interactor or participant at a given time. The Visionstation is a hemispheric display system fit for a semi-immersive visualisation which connects the display with a PC or a workstation. The visualisation is made by combining software, API and lens, creating spherical images and projecting pixels equally through the hemispherical screen surface. In each of these environments the focus of interaction is the capacity to perceive the virtual in a holistic and inclusive view. All of the details are visualised dynamically in 3D with a significant degree of user involvement. In this way it is possible to perceive and acquire information and data that would not otherwise be available.

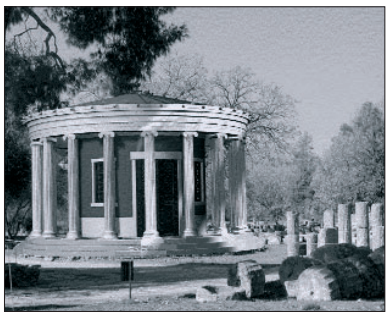
71 Some crucial statistics of the project are: 82,561 lines of code, 33,603 polygons, 3 GB of textures, 1.2 GB of audio, 100 menus, and around 500 links.

For evaluation, the team has two main criteria: a scientific evaluation concerning the feedback of 'virtual learning' in terms of information processing and a communicative-didactic evaluation, namely the customer satisfaction of the digital users and the quality of the cultural content in the digital world. For testing the VR systems of the Scrovegni's Chapel, the CNR team hopes to prepare an evaluation questionnaire for the visitors, which covers all of the 'musealised' areas, i.e. both real and virtual visits to the chapel. The team is also studying the possibility of monitoring the behaviour of the visitors with video cameras and recording their feedback/impact in a virtual museum. The multimedia/VR room of the Chapel was opening in Padua on the 25th of March 2003, and evaluation must include all the factors of interaction and memorisation of museum events according to narrative contexts. For this project it will be interesting to compare the virtual map that will be created during the interaction with the multimedia model and the real map relative to the real visit. In this case narrative thinking provides interesting and useful feedback, i.e. the faculty to 'tale' or 'narrativise' a virtual experience.

Future work for the TECBEC Lab of the **CNR-ITABC** includes the **Vettii House** in Pompeii, **Aksum** in Ethiopia, and the **Terramare Bronze-Age** landscapes. Fundamental goals of the various projects are:

- To increment the cognitive content of the virtual models in terms of interaction, dynamics and contextualisation;
- Real time and interactive analyses (archaeometric and spatial analyses connected with the 3D environment);
- Digital monitoring of the monuments on-site using DVR systems;
- 3D contextualisation, representation and visualisation of all the data available in an *OpenGL* environment;
- Scientific communication and visual publication of archaeological data using multidimensional metaphors.

As Forte puts it, 'The great challenge [for DVR] is to use desktop technologies for disseminating virtual reality systems and applications all over the world, integrating the entertainment of video games with the 'edutainment' of cultural models/projects, from VR centres to domestic daily life.'



Archeoguide overlays the user's actual surroundings with virtual representations to create an Augmented Reality experience

Case Study IV – ARCHEOGUIDE (www.archeoguide.com)[72]

The ARCHEOGUIDE project provides new approaches for accessing information at cultural heritage sites through the development of a system based on advanced IT. The techniques used in this system include augmented reality, 3D-visualisation, mobile computing and multi-modal interaction. The project ran for 36 months between 2000 and 2002 with a budget of €1.5 million, and was pursued by a consortium of European private companies, research institutes and public authorities. These organisations and their roles were as follows:

- INTRACOM (Greece) handled telecommunications and networking, multimedia databases, mobile computing, AR platforms, and system integration;
- Fraunhofer IGD (Germany) provided real-time image processing and video tracking;
- ZGDV (Germany) supplied AR platforms and rendering engines;
- CCG (Portugal) were responsible for avatar animations;
- A&C2000 (Italy) provided the Geographic Information Systems and GPS;
- Post Reality (Greece) dealt with 3D modelling and multimedia publishing;
- The Hellenic Ministry of Culture (Greece) handled archaeological data, system installation, and monitored use inside the test site of ancient Olympia.

The close collaboration between personnel from various disciplines, including engineers, computer scientists, graphics artists, archaeologists and architects ensured the technical, artistic, and scientific soundness of the final system and validated the information presented to its users.

ARCHEOGUIDE provides a special visualisation device which offers a choice between transparent AR glasses, allowing the user to see the natural environment with the computer graphics superimposed at appropriate positions, or opaque AR binoculars which provide the same experience in video see-through mode. Both devices provide a realistic experience wherein the user feels immersed in the augmented world, but at the same time has continual visual contact with the 'real' environment. The synthetic information is automatically projected onto the visualisation device based on the user's location and orientation. Using the tracking data, the system can identify the item at which the user is looking and adapt and reposition the synthetic image accordingly. The accuracy of this operation is typically of the order of a few pixels for an 800x600 image displayed on the visualisation device.

ARCHEOGUIDE features the following types of VR presentations:

- Virtual Reality (VR) navigation through a 3D model of the archaeological sites. All main monuments are reconstructed, and avatar animations are added. This is experienced on a flat screen;
- Augmented Reality (AR) touring, wherein the real scene is augmented with reconstructed monuments and virtual life animations. This is experienced through AR glasses or special binoculars;
- Mixed Reality (MR) presentations, wherein the real scene is augmented with reconstructed monuments, but can be seen on a flat screen which is automatically scrolled in synchronisation with the user's own orientation.

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72 This case study is based on an email questionnaire completed by Dr Vassilios Vlahakis of the Development Programs department of INTRACOM S.A. Subsequent background information has been gleaned from the ARCHEOGUIDE Website.

Additional effort was needed for the development of the real-time tracking system, which is used for tracking the mobile users of the system. The algorithm is based on markerless image analysis in the frequency domain, and achieves high accuracy and efficient performance in the presence of occlusions, motion and rotation. Another time-consuming task was the integration of the individual software and hardware system components, and their adaptation for operation in uncontrolled outdoor environments.

The design of the system and the choice of the various technologies and software and hardware components were made by consensus via the technical partners. Experience and know-how were used together with market research and testing of existing components. The initial choice was further refined based on user feedback, new developments in the field and new hardware appearing in the market. The partners participated in major conferences and exhibitions in fields related to the project and made contacts with other leading projects and research teams studying virtual reality, augmented reality, mobile computing, and more specifically with cultural heritage applications of these technologies. This process still continues, with an aim to producing a commercial version of the system.

The ARCHEOGUIDE project was initially conceived as a mobile augmented reality guide and tour companion. The system was designed and developed with this definition in mind and the first prototype was built based on a top-of-the-range laptop and special AR glasses. During the evaluation of this prototype it became evident that the size and weight of the equipment would be too great for a number of its intended users. Based on that and the fact that lighter and more compact devices with sufficient processing power were unlikely to become available in the market before the end of the project, the consortium considered lighter versions of the system making use of virtual and mixed reality. These were built on pen-tablets and PDA's, and feature the same information with the AR devices presented on touch-sensitive screens which are easier to carry, suitable for outdoor viewing, and have a user-friendly interface built around graphical bookmark tabs. Despite the fact that they lack the immersive aspect of the AR devices, they offer high quality, location and orientation sensitive presentations adapted to each user's personal profile. Finally, a new kind of AR device was considered and implemented, and the old AR glasses and associated head 'gantry' were replaced by compact AR binoculars. These offer an identical experience, but are more user-friendly and provide better contrast for outdoor use in sunny weather.

In terms of personnel requirements, the project's needs were generally covered by the partners' existing staff. As a result of time limitations and the lack of available special hardware some minor tasks were performed by contractors. Such tasks included the aerial photography of the site of Olympia, where a private firm undertook the task of photographing the site from an aeroplane. Another example was the scanning of museum artefacts for the creation of accurate 3D. For system maintenance after installation, much of the content creation and organisation can be performed by the staff of the site where the installation will be performed following training with the editing and authoring tools. Setting up new devices or extending the coverage of the system requires the support of the consortium's engineers. In the future they hope that this will not be the case.

In terms of implementation and evaluation, ARCHEOGUIDE has met its main goals of the production of a mobile AR platform suitable for outdoor applications, implementation of AR, VR and MR tours of archaeological sites, user friendly operation, a multimedia database of cultural heritage information, and graphical tools for content creation, management and virtual reconstructions. The final product has been warmly accepted by

scientists and members of the public, and the technologies that were developed and the expertise that was gained could be exploited in other applications in the areas of education, tourism, interactive e-commerce, training and guidance of industrial workers, mobile computing applications, and multimedia publishing.

During the project's research and development (R&D) cycle, the system was extended from pure laptop-based AR to lighter devices, providing increasingly user-friendly operation and addressing the needs of different categories of user. The system was evaluated under real operating conditions at the archaeological site of Olympia by a wide range of potential users, comprising ordinary visitors, archaeologists, computer experts, VR and AR developers, and staff at the site. Very positive feedback was received and almost all confirmed their intention to use the system once installed. Some negative comments were received on the size and weight of the AR devices, and several new features and improvements have been implemented based on these comments. This is a continuous process, and one which will go on even after the first full scale installation, expected to take place in 2004.

ARCHEOGUIDE has been presented to several international conferences and exhibitions where it attracted attention and interest from participants. Currently, several major cultural heritage sites and museums across the world have expressed an interest in installing ARCHEOGUIDE. The consortium is seriously considering these prospects and is currently working towards an improved system version in which more compact, lighter and powerful devices will replace the existing ones. This work will continue with the eventutal aim to employ 3G mobile phones in the future as the main platform used.

Based on the ARCHEOGUIDE results and expertise, a new concept has been born, that of a mobile AR system offering the same navigation and reconstruction capabilities but putting emphasis in the revival of ancient life through AR techniques, story telling and real-time photo-realistic modelling of human behaviour and appearance as well geophysical surroundings. This work comes under the title LIFEPLUS and will be developed and tested at Pompeii, Italy. Beyond the cultural heritage field, ARCHEOGUIDE has lent its technological know-how to interactive AR for decoration and furniture retailing through the ARIS project. This project is still in its early developmental stage but aims to give its users the ability to decorate their space with furniture bought from an on-line catalogue. Three-dimensional items can be manipulated in real time, and the augmented world is visualised through special AR glasses. Other new ideas are currently under consideration so that the full potential of AR and VR can be exploited.

Scenarios

Scenario I – Museum

A large municipal museum has taken the significant and difficult decision to close its doors to the public for a year in order to refurbish, and modernise the building's interior. The museum was built over one hundred years ago, and the space is not being used to anything approaching its full potential. Coupled with this, the building's electrical infrastructure is not capable of handling the increasing demands of a twenty-first century institution and will need to be completely replaced. Before the museum closed to the public, the planning team identified an opportunity to make the most of the closure and reorganise the held objects and numerous thematic routes that visitors may follow through the collections.

In order to do this with maximum success, a VRML model of the museum was suggested, which would allow the curators and architects to reach a consensus on the optimal deployment of resources while at the same time giving an accurate indication of the pathways and lines-of-sight that different types of visitor (adults, young children, wheelchair users) will be presented with. This is accomplished through the intelligent use of avatars during the design stage, as well as collaboration with patron groups such as the Friends of the Museum.

An external expert is commissioned to construct a minimal model, suitable for use in guided 'fly-throughs' but not initially fully explorable. This allows the planning team to gain a quick overview of the options available to them. While the planners consider the next move, the VR expert extends the model to become fully interactive and navigable, and links it to a database of the museum's most valuable and best loved objects. The digital objects can then be virtually placed in a variety of locations within the model, thus adding further value, variety and reusability to it.

Finally a selection of avatars is created to represent different categories of users, and with these the different potential layouts can be explored to ensure that they are attractive and negotiable for all user groups.[73] If properly planned and if funding permits the virtual museum model may eventually be optimised for delivery via the Web, and perhaps tied in with a number of QTVR panoramas and object movies to add a sense of realism to the explorable capabilities of VRML.

Scenario II – An observatory

Halley's Comet is on its way back towards Earth again, and a university-run observatory hopes to cash in on this rare event by opening its doors to the public, allowing them to view the spectacle through their powerful telescopes. The staff have two years before the comet is visible, and want to begin publicising the event as soon as possible.

The first step is to add a special 'comet-watch' counter to their Website, coupled with a little information about the observatory, the comet, and its place in history at the Battle of Hastings as recorded on the Bayeux Tapestry. In collaboration with the university's departments of Medieval History, Computing Science and History of Art, the Astronomy department begins to create a series of Web-delivered QuickTime movies which allow the user to follow the comet's path around the galaxy from a variety of angles and viewpoints. They let them track where the comet was on the date of the user's birth or any other date of significance to the user.

As the astronomy department holds a large collection of images of the comet, and is able to track its position continuously, the creation of explorable QTVR panoramas and non-interactive movies should not prove too onerous a task. The necessary equipment is already in the possession of the various departments, and the technical and historical know-how is already in place. The most difficult aspect of such a project is likely to be the collaboration between radically different departments, although the success of such an interdisciplinary venture will surely pave the way for future inter-departmental co-operation on a similar or even a larger scale.

73 Since the building is so old, wheelchair access is a concern for the planners.

Scenario III – A castle and visitor centre

A castle in a remote area is in desperate need of roof renovation, and the trustees are having difficulty in drumming up the necessary cash to carry out these necessary repairs. A new visitor centre, a few kilometres along the road, is having its own difficulties. Despite the area's rich historical significance and great natural beauty, the centre finds that its visitor numbers are dwindling. The two organisations decide to team up and launch a co-authored Website. Considering the amount of time they have on their hands during the wintertime, learning basic Web-authoring skills is not a problem for the staff of either attraction, and this is done via free online tutorials.

The next step is in deciding how best to market the area and its attractiveness to potential visitors. In collaboration with the area's tourist board, the organisations decide to commission a VRML model of the castle with a photorealistic background, allowing Website-visitors to explore the area and to view it in its natural context. While 'inside' the castle, visitors can learn about the area via interactive learning links provided by the visitor centre and tourist board.

As a result of this collaboration the centre's visitor numbers increase significantly, and the majority of these new visitors will continue on to visit the castle, perhaps even spending a night in a local bed and breakfast. This leads to increased donations for the castle's roof appeal as well as an overall boost in the local economy.

Scenario IV – A national theatre and cinema

A recently independent country is in the process of planning its new national theatre, and the advisory board wishes to incorporate some of the most attractive and celebrated elements of famous theatres from around the globe in its design. The theatre will also double as a national cinema, and will incorprate a development/resource unit for aspiring filmmakers. The new government is determined that the venture will be a success, and has committed a significant amount of funding to the project.

Using an adaptable VR model, the designers and steering committee are able to visualise the sightlines of the theatre in relation to its various components, and to move these components interactively using haptic feedback technology and three-dimensional displays. In addition, the haptic interface allows the designers to resize components in real-time, and the output of the system can be accepted as input into an architectural CAD application. This latter tool can be used to validate structural soundness and viability.

The result is a collaborative effort which has involved all interested parties in the design of a valuable national asset, and one that will hopefully remain in the hearts and minds of citizens for centuries to come as a symbol of their heritage and aspirations.

Benefits and Risks

Benefits of VR

First and foremost VR provides an effective conduit for humanities learning, bringing the past to something close to life and allowing students to experience the past interactively and, at best, intuitively. VR affords societal groups such as the young or the disabled

the opportunity to explore and learn in ways that they may otherwise normally find difficult or impossible.

VR can reduce the cost of delivering training by decreasing learning time for trainees and instructors, and travel costs may be reduced if the virtual worlds and environments are made available across the World Wide Web. As a training aid or mechanism, VR has potential in a broad variety of sectors. Training in a virtual environment reduces the risks of real-life training which may be potentially dangerous or unmanageably expensive otherwise.

Risks and limitations

VR worlds that attempt to meet all of Sanders' conditions (see above) will be complicated, costly, and have large file sizes. In terms of learning, quality hardware and software may be outwith the budgets of educational authorities or institutions. Developers not only have to nurture an extensive technical knowledge, they also need to appreciate how human perception works if their models are to be effective.

Another problem is that it will be complicated and demanding to create a virtual world in which participants can interact fully with each other. Cost is not always a fundamental problem, but simulating some effects that are familiar to the human body will plague VR applications for sometime to come.

Immersive VR systems can impact on health. So, just as VDU users are advised to take screen breaks, VR developers, testers and users should take frequent rests in order to minimise the occurrences of commonly reported symptoms, headaches and nausea.

Tabular overview

Benefits	Risks
Educational. VR provides an excellent pedagogical tool that students respond to with genuine enthusiasm.	Potentially difficult to do. Question of whether to train staff or use external people.
Design. Funds can be saved by constructing VR models rather than genuine prototypes.	Can be costly. Research will need to be done to determine the most cost-effective VR solution.
Improved 'access' to distant and/or historical sites.	Outsourced VR models may not be adaptable by in-house staff.
Performance. VRML in conjunction with cyberspace offers a new approach to the performing arts.	Web-delivered VR is not yet at an optimal level.
Avatars and user-profiling encourage interaction among geographically and culturally distant users.	
QTVR is easy to use and provides immediate and realistic context of a scene.	

Introducing the Technology

Selecting a 3D specification

When making the choice about which VR/3D specification to employ the following questions are worthy of consideration:

- Is the technology platform-independent? Is this necessary/desirable?
- Does it render identically across different platforms? Is this necessary/desirable?
- Does the technology support integrated multimedia?
- How easy is it to program, and will existing staff be capable of this?
- How high are the development costs?
- Is the technology Web-friendly?
- Does the technology require dedicated software for display?
- What are the hardware requirements?
- What is the state of standardisation?
- Does the technology have a recognised/recognisable file format?
- Are the worlds immersive and fully navigable? Is this necessary/desirable?
- How high performance must the finished product be?

Distribution issues

Before the advent of the Internet, VR worlds were all held discretely and accessible only by those physically close to the host computer. Now more than ever virtual environment design must also address issues of distribution. Decisions about **CGI**, **Servlets** and two-tier versus three-tier architecture will be dependent on the intended user base, such as whether the model should be accessible over the Web or, for example, in a stand-alone cabinet in a museum. Will it be desirable or necessary for the world to be capable of hosting concurrent visitors?[74] These are crucial design issues, and will impact on the technical as well as the aesthetic or pedagogical successes and/or failures of the virtual venture.

Interfacing issues

Most VR systems and certainly the overwhelming majority in Web-distributed VR applications are navigated using the standard PC mouse. A mouse is only capable of motion in two dimensions – how then can this be reconciled with the illusion of a three-dimensional world? Dedicated controllers may be employed, perhaps featuring some simple haptic force feedback for the user.[75] Interface design is a key issue, and various intuitive interfaces should ideally be available for different types of user from children to specialists.

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74 Blaxxun provide a free plugin which allows concurrent multi-user 3D rendering.

75 Haptic devices, which replicate the sensation of 'touching' virtual objects, may also be used to experience virtual worlds. Haptics will be covered in detail in DigiCULT Technology Watch Report 3, available from August 2004.

Of course, a number of interfaces exist which are specifically geared towards the VR market. Head-tracking displays generally resemble helmets (although some smaller head-mounted interfaces more closely resemble a large pair of sunglasses), and contain small, high-resolution monitors which are necessarily positioned close to the user's eyes.

Data gloves contain sensors which pass over joints in the user's hand to measure the position of the fingers and hand across six axes. The user's movements are translated into coordinates using devices called *trackers*, are the resulting data are then fed back to the computer so that the model of the virtual world can be updated.

Projected systems, found most often in larger museums, take an image of the user's motions and display this image alongside other images on an oversized screen. Virtual reality *simulators*, commonly found in video gaming arcades as well as airline flight training, take this approach one step further. They employ a combination of display monitors and movable 'pods' to create increasingly realistic experiences by adding the capacity for motion to the VR equation.

Staff and policy issues

The introduction of virtual reality and/or other display technologies are unlikely to have any effect on an organisation's policies or strategic arrangements. The pressing issue for CH organisations is overwhelmingly likely to be that of staff experience and training. For many cultural heritage applications of VR technologies, dedicated staff will be required to construct the actual models. This is a specialised task, and funds must be set aside for in-depth training of existing staff or bringing in external expertise from a dedicated consultant/programmer. This can be expensive, both in terms of money and of lost working time when members of staff are kept away from their regular duties. Sending staff on training courses can be very expensive, and the usefulness of independent learning aids – such as VRML author Chris Marrin's book *Teach Yourself VRML 2.0 in 21 Days*, and other tutorial material available free-of-charge on the Web – should be investigated prior to this. The Authors' experience of the current generation of online learning materials is very positive.

Virtual reality need not be an overly expensive business, and useful models can be built by small teams or individuals. The fundamental issue is to settle upon a required end-result *prior* to beginning development, and the choice of technology used will be of key importance.

Human Interfaces

Executive Summary

The processes and devices used to interface humans with computers have been a concern of computer scientists since the birth of computing itself, and human-computer interaction (or HCI) is a field undergoing a process of rapid development. Never before has access been available to such a wide array of devices, all with different technical capabilities and underlying concepts. Recent HCI developments can be best characterised by three primary characteristics, these being the goals of user-centred design, the appeal to multiple human senses, and the struggle for portability.

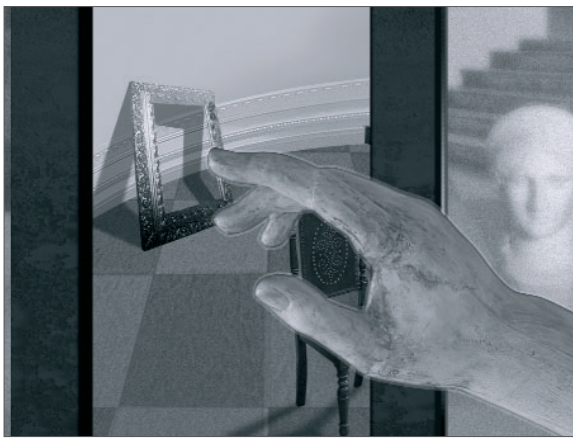
Development of new devices is often driven by the needs of different areas of computer science, the most influential of which are currently multimodality, ubiquitous computing, computer-supported co-operative work, virtual environments and augmented reality. Each of these fields has a great deal to offer the presentation of and interaction with cultural heritage resources.

The technologies presented below have different fields of rapid development resulting in new equipment and dozens, occasionally even hundreds of producer brands. Rather than providing detailed information on all of these developments, this report will describe some of the emerging technologies with a focus on those forecast to be the most effective and usable in the current technology setting. It indicates their possible future applications in cultural heritage organisations. Devices covered include head-mounted displays, shutterglasses, CAVEs, speech input systems, wearable computers and brain-actuated control.

The cultural heritage sector has a number of reasons for following these new developments closely. The introduction of new technologies can assist the work aimed at providing visitors with tools for observing collections not currently on display, studying collection items which have restricted access and handling conditions, acquiring additional information on the collection items, or creating personalised tours which could be used in future visits or for additional study at home.

The introduction of these new interaction technologies will allow users to navigate through collections following their preferred learning style. The appearance of many novel interfaces must be met with intensive measurement of the health risks which can be caused by the physical peculiarities of the devices, or by the effects of immersion in virtual reality worlds. These discomforts may manifest themselves physiologically, psychologically, or both.

While the discussion focuses mainly on the possible influences of new interfaces on museum visitors, we outline the potential impact these technologies may have on the everyday work of museum and library staff members.



An Introduction to Human Interfaces

The role of human interfaces

Human-computer interfaces are at the crossroads of a number of fields of computing science such as ergonomics, computer graphics, operating systems, human factors, and cognitive psychology. In the early days of computers the basic input devices were paper tape, punch cards and the keyboard, but now the most common interfaces are the keyboard, mouse and gaming-console controller.

A key factor in the recent development of human-computer interaction technologies is the concept of user-centred design, a concept based on four primary design principles:

- A clear understanding of user requirements and tasks being solved;
- Incorporating user feedback to refine requirements;
- Involvement of user in formative evaluation of the design; and
- Integrating user-centred design with other development tasks and activities.

While the significance of these principles to the design and development of Human-Computer Interaction (HCI) devices appears obvious to us now, this has not always been the case. Some predicted improvements in HCI include better quality of interaction, easier use and increased speed. The last of these seeks to allow users to spend less time on human-interaction tasks and more on new experiences. This is often facilitated by involving more of the user's senses or via total immersion in the computer environment.

It is interesting to note that while new devices often emerge specifically to answer the needs of a set application area, developments in these areas usually provide powerful feedback for ideas about human-computer interaction in general. Computer graphics have fulfilled such a role in the past. Now, multimodality, ubiquitous computing, co-operative work, and virtual environments, including cyberspace and augmented reality, are rapidly developing and arousing interest in creation and use of new devices that will continue to change the range of concepts of human-computer interaction.

Multimodality: the stimulation of multiple senses

The past decades have been marked by a fundamental reliance on the visual output from computer systems. Visual devices such as monitors have been and remain the most popular output devices, used in combination with the keyboard and mouse as means of data input. The introduction and recent developments of graphical user interfaces (GUI's) mark a clear tendency towards overload of the visual channels. As the ability of technology to handle images, audio, and video improves increasing attention is being paid to the development of support a wider array of multi-sensory data including odours, texture, and space. This does not mean that visual technologies are being left behind. In fact, they are continuing to be developed in order to achieve greater reality and portability.

Ubiquitous computing

Ubiquitous computing is often defined as the flipside of virtual reality. Mark Weiser, the inventor of the concept explains, 'Where virtual reality puts people inside a computer-generated world, ubiquitous computing forces the computer to live out here in the world with people. Virtual reality is primarily a horse power problem; ubiquitous

computing is a very difficult integration of human factors, computer science, engineering, and social sciences.'[76]

The basic idea behind this concept is that technology should recede into the background of everyday life. This is connected significantly with the widespread introduction of devices which are intuitive to use and do not require any special training and skills. This naturally leads to a great interest in the development of innovative interaction styles and equipment, such as those connected with senses which are often underused such as motion and smell.

Since this concept is linked to communication through both local-area and wide-area networks (LAN's and WAN's), opportunities related to computer-supported co-operative work are closely related to ubiquitous computing.

Computer-supported co-operative work

A natural focus is now put on interfaces which permit and facilitate co-ordination and shared work between groups of people for use in, for example, meetings, engineering projects, and activities in which joint authoring may be an advantage or even a necessity. In a museum this could be oriented towards visits of groups who would be able to discuss their impressions, and to enhance them by connecting them to their experiences of other collections. Applications in this field are keenly anticipated and will result in new practices for joint study of specific collections.

Virtual Environment technology

Virtual Environment (VE) is aimed at the development and exploitation of computer-generated synthetic environments. The basic goal of developing such systems is to allow users to interact with these environments in natural and easy ways and, in this respect, interface issues play a crucial role. Probably the basic reason for such interest in VE systems is that they open up new application areas which were deemed too expensive or dangerous before. Virtual environments which present ancient artefacts in detail could be a typical application for the cultural heritage community.

Current expectations of enhancements to the technology suggest that well-designed VE's could provide more intuitive metaphors for human-computer interaction. For the cultural heritage field this would mean a broadening of the group of possible users, the improvement of mechanisms of communication between users, and interfaces to computer systems becoming more straightforward and natural.

VE's can be divided into three classes differing in the sense of immersion they provide: non-immersive, semi-immersive and fully immersive. Immersion is measured by the power of attention that the user focuses on his or her activity. As well as the display characteristics, other factors contributing to the sense of immersion will include image quality, the number of dimensions, the number of degrees of motion, and the overall level of interactivity of the system.

Non-immersive systems are the weakest of the three, with an example being those observed on a desktop computer using a standard high-resolution monitor. Interaction with the system is based on the use of the keyboard, mouse, or a joystick, coupled with a dedicated browser which allows the computer to render a virtual world from its source code. As far as new devices go, datagloves complement such systems. Data gloves contain

76 http://sandbox.xerox.com/hypertext/weiser/UbiHome.html

sensors which pass over the joints in the user's hand, and measure the position of the fingers and hand across six axes. The movements of the users are translated into coordinates using devices called trackers and the resulting data are then used to enable interaction with the virtual world. Semi-immersive systems involve large screens of multiple projection systems and shutterglasses (see below for an explanation), thus providing a heightened sense of immersion and interaction overall. Fully immersive systems currently are based on the use of head-mounted display (HMD) technology. These allow for the highest (or deepest) level of immersion, although the image quality tends to be less convincing in comparison with less immersive systems.

© Archeoguide

The Archeoguide user-interface

Augmented reality

Augmented reality is another concept best considered in contrast with virtual reality. Unlike VR and its entirely computer-generated experiences, augmented reality employs modern computer and display technologies to supplement the user's perceptions of her actual surroundings.[77] As will be evident from the ARCHEOGUIDE case studies, augmented reality combines the real scene as viewed by the user with virtual scenes generated by the computer to create an enhanced composite view. While ubiquitous computing puts the accent on the 'invisibility' of the computer, here the accent is on the quality of the supplied content and the flexibility with which it can be used. This variance in focus does not alter the debate over which particular devices can be best used to assist the user in her quest for information.

How do these interfaces work?

Introduction

Despite the widespread adoption of WIMP (Windows, Icons, Mouse, Pointer) interfaces, the struggle to make computers easier to use continues. Future computer systems should make more effective use of all human sensory channels and provide more intuitive, easier to use interfaces that go beyond the current WIMP standards. Effective future human-computer interfaces require new interactive systems that deal with the hardware, the software and the system-level interactions between the two.

One current tendency for computer hardware is that it is *miniaturising*, i.e. becoming less cumbersome and more portable. What was on the desktop yesterday, is on the laptop or palmtop today and will be on the wristwatch or ring tomorrow, fully integrated with the home PC and the Internet.

Computers are traditionally controlled by hand, using a keyboard, a mouse or a trackball, while information is output typically on a display screen and/or printer. Nowadays, this standard set-up has gained new dimensions with emerging technologies having led

77 Please see the DigiCULT Case Study on ARCHEOGUIDE in the previous chapter for more on Augmented Reality.

to significant changes in classical man-machine interfaces. It is opening new opportunities for the implementation of computer technologies.

Devices are traditionally placed in *input* and *output* groups. The new tendency is to combine these into devices allowing both input and output. Touchscreens and HMD's would be examples. With reference to the various human senses that the human-computer interaction devices exploit, the following different technologies can be defined.

Visual interface technologies

The current focus on the visual communication channel in HCI has not prevented a significant amount of development in other technologies currently on the market. There are several broad aims, including increasing screen sizes and resolution, making displays three-dimensional, and implementing new technological approaches.

One of these approaches aims at very large and very thin displays that will lead to improvements in portability and enable development of paper-like, pen-based computer interaction systems very different in feel to today's desktop workstations. This trend dates back to 1963, when Ivan Sutherland created *Sketchpad*, an interactive drawing tool which enabled users to draw points, line segments and arcs on a cathode ray tube with a light-pen. The device that popularised and brought this type of interface to the public eye was the **Apple** *Newton MessagePad*. More recently, the **3Com** *PalmPilot*, with an even smaller display than that of the *Newton*, has become a very popular pen-based platform. Its applications have very few on-screen controls and the pull down menu at the top of the screen is normally hidden. The *PalmPilot* does not recognise normal Latin letters but uses its own Graffiti character set , entered in a dedicated area of the screen. Its core applications are the same as the Newton's. Pen-based interfaces have been used in a number of other computer applications, including word processors, spreadsheets, music editors and air-traffic control systems.

Another track of work is on devices which give more realistic images and encompass spatial positioning. They are often described as 'three-dimensional' (3D), although not all devices support 3D visualisation. This report concentrates on two innovative types of computer visual devices:

- Devices which actually produce an image by themselves (Head-Mounted Displays and helmets). These contribute to building immersive VE's;
- Glasses which transform the way the user sees the image on a standard monitor (Liquid Crystal-Shutterglasses). They contribute to the development of semi-immersive VE's.

One type of semi-immersive or immersive VE display suitable for the culture environment is the Computer Automatic Virtual Environment, or CAVE for short. Developed by the University of Illinois in Chicago, the CAVE consists of up to six large display screens arranged in a cube. Stereo graphics are projected onto each screen, and multiple users can stand in the middle of the cube and engage with the VE. If additional head-tracking technology is provided for one of the users, the perspective will change in sympathy with the movement of his or her head.

In addition, there are the *Chameleon*-type displays for VE use. These employ a handheld display whose position and orientation details are tracked in order to determine what appears on it. Additionally, the display may enable interaction with what it is showing. This technology is not as revolutionary in the display type or specifications as in the combination of tracking, visual output and interaction.

Advances in computer displays have lagged behind improvements in processors, storage capabilities and network bandwidth. Researchers have begun to focus attention on enhancing display technologies. Among new technologies launched in recent years are *electronic ink*[78], *organic light-emitting diodes* (OLED's)[79], and *light-emitting polymers* (LEP's)[80]. These should lead eventually to the creation of more power-efficient, cheaper, and higher resolution displays. The focus on cheaper and more malleable materials may make it feasible to make display devices ubiquitous and to use them in more creative ways.

Keyboard and mouse interface technologies

Some of the most interesting contemporary work is geared towards the development of virtual keyboards and mice, devices which support the common keyboard metaphor but without the keys. A traditional keyboard is not convenient or practical in the case of smaller computers so serious interest is being taken in new alphanumeric interfaces including Graffiti handwriting, or alpha-numeric keypads similar to some telephone phone keypads.

Mathias Kölsch and Matthew Turk of the University of California, Santa Barbara, have carried out an interesting survey on different technologies involving the use of virtual keyboards.[81] A doctoral study by Robert Rosenberg of University College, London has identified a number of approaches and devices which may hold future relevance for the cultural heritage sector.[82] Photoelectric sensors, active finger tracking methods, gyroscopes and laser technologies are amongst the technologies used for developing virtual keyboards. The Visual Panel consists of a camera and a sheet of paper, and computer vision tools locate the position of the index finger in reference to the paper.[83] The Chording Glove is based on attaching pressure sensors for each finger of the hand in a glove (see Rosenberg). The Finger-Joint Gesture Wearable Keypad (see Goldstein *et al*) uses thumbs which treat the phalanges of other fingers as virtual buttons to be pressed.

VKB[84] offers a virtual keyboard based on laser technology that can be projected and touched on any flat surface. A keyboard image is projected from a handheld or other device onto a flat surface, and an optical-recognition device detects which 'keys' the fingers hit. Such a keyboard can be integrated into laptops, mobile phones, or PC's. It is anticipated that such keyboards will in time gain a broad user community, including the cultural sector. Another area of innovative work is on *eye tracking*, which is presented in the motion tracking interfaces section, below.

The video camera as input device

Video cameras have already been used as input devices in cultural heritage organisations, notably and successfully in the **Zeppelin Museum** at Ludwigshafen, Germany. The set-up consists of a video camera that takes photographs of the visitors and attaches them to electronic greeting cards, which can later be sent to relatives or friends. This museum

78 See, for example, http://www.eink.com/technology/index.html
79 See http://www.almaden.ibm.com/st/projects/oleds/competition/index.html
80 See http://www.chemsoc.org/exemplarchem/entries/2001/williamson/
81 http://www.create.ucsb.edu/sims/PDFs/Koelsch_and_Turk_SIMS.pdf
82 'Computing without Mice and Keyboards: Text and Graphic Input Devices for Mobile Computing', partially available at http://www.obscure.org/rosenberg/toc.pdf
83 See Zhang et al, 'Visual Panel: Virtual Mouse, Keyboard and 3D Controller with an Ordinary Piece of Paper'
84 http://www.vkb.co.il/

service is well liked by visitors, and demonstrates an innovative way of attracting visitors, making their visit to the museum as pleasant and memorable possible.

The **Sony** *Eye Toy* is another interface which employs an advanced form of camera-based input. It consists of a USB video camera connected to a TV set. Users (players) can see themselves on the TV monitor and are thereby quasi-immersed in the ongoing game. Sony hopes to offer a package containing the USB camera and 20 suitable computer games at a reasonable price in the coming year.

Auditory interface technologies

These technologies can refer both to audio input and to audio output, but it is the development of the former type which will be presented briefly in this report.

Haptic interface technologies

Haptic interfaces enable manual interaction with virtual environments via force-feedback technology. Haptic exploration is a sensory task which involves the identification of surface or volumetric properties. Examples of haptic devices are joysticks and data gloves equipped with sensors which trace the movements of the hand and communicate them to the computer. They are widely used for manipulation of the movements in VE's, most noticeably in video game controllers.

Motion-tracking interfaces

Human movement tracking systems are those that generate data representing the user's body movements. In general, such systems consist of sensors and/or markers or sources either on the body or externally, and a computer holding the interface and stored data on the human movement.

Human movement tracking systems can be classified as inside-in, inside-out and outside-in systems. With inside-in systems, both sensors and sources are worn on the body while in the inside-out systems sensors are placed on the body but react to an external source. These systems work by attaching equipment to different parts of the human body and could be considered as more obtrusive. In the outside-in systems external sensors sense sources on the body: these are less obtrusive in use. Current technology offers dozens of different solutions for body tracking.

Dedicated motion-tracking interfaces such as the Eye Mouse track ocular movement and translate it into signals to the computer. Such devices are of particular value for users who may have difficulties using a mouse, trackball and/or keyboard effectively. It may even free able-bodied users from being stuck behind their desks.

Olfactory technologies

Smell is not yet actively used in human-computer interaction, probably because the world around us is full of all sorts of odour stimuli. Nonetheless a controlled presentation of olfactory information can give advantages in various application fields. Two technologies in this field have been developed: electronic noses and virtual olfactory displays.

Electronic noses are emerging devices which can be used to measure the quality of a product or a process. They will find their place in the food production, environment studies and other activities involving analysis of odorants.

Virtual olfactory displays are systems which consist of hardware, software and chemicals, and which are able to present olfactory information to the user of a Virtual Environment. In the heritage sector, an electronic nose could conceivably be used in

condition control for the storage of fragile collections, while virtual olfactory displays could be used to assist in the increasingly realistic presentation of VE's. Such applications remain some distance away practically.

Mixed interfaces involve the stimulation of several sensory channels at the same time. (See the discussion of brain-actuated control below.)

Wearable computers can act as standalone computers and need not just function as communications devices. They combine several different technologies such as those classed as Personal Digital Assistants (PDA's).

The importance of human interfaces in cultural heritage institutions

The field of human interfaces develops so rapidly that dozens of new devices appear on the market each year. This presents cultural heritage decision makers with the difficult choice of whether or not to equip visitors or staff with new devices and, equally importantly, which devices to invest in. A strong impetus for introducing new interface devices to cultural institutions would be to provide visitors with tools for:

- Observing collections which are currently not on display. This might be done at different levels of detail, and could involve a mix of traditional and new technologies. Typical examples for this are multimedia kiosks involving use of touchscreens;
- Studying items subject to restricted access and handling guidelines. This may involve specialised projection equipment, as well as equipment capable of providing tactile stimuli, for example, a combination of HMD's and datagloves.
- Acquiring additional information on the items in the collection using multimodal presentations that provide data that can be used to engage more senses;
- Creating personalised tours which could be used on future visits and for additional study at home. This may also involve tracking or positioning technologies and storing this data for later reuse in generating personalised virtual visits.

The most typical applications are information kiosks in museums and self-service machines in libraries, such as the online touchscreen catalogue in the main reading room of the **Library of Congress**[85]. Additional benefits are noted where the introduction of technology might be of help to disabled users, the very young, or the very old.

Where are new human-computer interfaces used?

Applications for innovative interfaces may be identified in virtually every sector of industry, commerce, services and cultural heritage. Many technological novelties have their genesis in military applications, and human interfaces are no exception. The potential for training in VE's that simulate potentially dangerous and/or expensive real world environments are an obvious demonstration of this. Another typical application field is in medicine, often referred to as tele-medicine. Interface improvements have been made in the fields of information management, business applications, marketing and sales, finance,

85 http://www.loc.gov

decision support systems, engineering , architecture, and education.

Typical applications can be placed in the following groups:

- **Public Information:** Many people who do not have computer experience use information kiosks at tourism and trade shows. The user-friendly touchscreen interface facilitates the transfer of information.
- **Games and Edutainment:** Attractive interfaces giving the impression of virtual or augmented reality are becoming more and more popular. Because new interfaces are more user-friendly, interactive learning can be presented as more fun. This makes the application very appealing for serving children and can be useful for distance learning.
- **Self-Service Terminals:** Self-service terminals improve customer service in stores, fast food restaurants, transportation hubs and at ATM's (Automated Teller Machines). They are increasingly used in libraries for retrieving catalogue information.
- **Control and Automation Systems:** New devices are applied in industrial process control and in the automation of home devices. With these systems users can monitor and control complex operations.
- **Users with Special Needs:** New technology can be beneficial to people with difficulty in using devices such as a mouse or keyboard. When used in conjunction with virtual keyboards or eye tracking, computing resources can become increasingly useful to people who, for whatever reason, have difficulty using computers.
- **The Cultural Heritage Sector:** According to recent survey data, approximately one third of museums in the USA use or are interested in exploring the use of innovative technologies. A steady increase in the introduction of these devices can be expected.[86]

How it all works

A. Visual technologies

According to Gartner Group research, the basic transformation in the IT industry over the coming decade (2003-2012) will be closely related to the availability of cheaper display technologies. Consequently, this report places emphasis on issues of new visual technology.

Touchscreens

What is Touchscreen Technology?

The touchscreen is the simplest and most direct way of interacting with a computer. The technology has been with us since the 1970s and the principle of operation is age-old: point at what is wanted. The touchscreen combines the roles of input and output device. Its use is intuitive for virtually every child and adult.

86 The sector which involves the most ubiquitous use of such new equipment is that of amusement and recreation, and the links between computer games and human interfaces in the heritage sector are covered in detail in the section on Games, below.

How it works I: the components

A touchscreen system will consist of five basic parts:

- The touchscreen itself.
- A computer (typically a PC) whose display is fitted with the touchscreen;
- A controller card which drives the touchscreen and converts each touch into coordinates;
- A software driver program which communicates between the controller card and the computer's operating system.

Where are touchscreen systems used?

Companies in various industries have successfully used the power of touchscreens for a wide variety of applications. Airlines use them to simulate aircraft cockpits and to train pilots to fly. Real-estate agents use them to show full-colour property images to home-buyers. Greeting card companies allow customers to create their own unique cards on them. Restaurants have them to simplify their point-of-sale terminals, and medical schools teach student nurses how to respond to crisis situations.

Current scope and future development of the technology

In the early 2000s, several distinct trends are likely to define the fast-growing touch-screen marketplace. Prices will continue to drop steadily as volume and production builds. At the same time, touchscreen performance capabilities should increase further. This favourable shift in price/performance ratios will boost sales, particularly as PC's make forays into uncharted territories where user-friendly interfaces are vital for inexperienced or disadvantaged computer users.

Touchscreen comparison

The most popular touchscreen technologies and their respective attributes and uses are listed below.

	Surface wave technology	Resistive technology	Capacitive technology	Infra-red technology	Projected capacitive technology
Principle of operation	Acoustic waves are propagated across the surface of a clear glass overlay.	A transparent, conductive layer senses the contact and computes X and Y co-ordinates.	Sensitive to the small electric charges on the fingertips.	Infra-red waves are propagated across the surface of the screen.	Similar to the capacitive technology.
Advantages and disadvantages	Clarity and durability. Toughness and reliability. Drift-free performance. Can be activated by gloved hands.	Cost-effective. Consistent and durable performance. Can be gasket-sealed for added protection.	Good Optical clarity. Good resistance to liquid and chemical contamination. Good resistance to vandalism.	With no screen overlay, for best possible image quality. Polycarbon overlay where vandal proof build is required. Works with finger, gloves or any stylus activation. Higher cost than Capacitive/ Resistive.	Good optical clarity. Works with gloved hands. Can be fitted behind protective glass, polycarbon will still work. Highly vandal resistant.
Applications	Highly graphical public display systems. Shopping mall directories. Video-gaming terminals. Computer-based training systems. Catalogue shopping systems. Video lottery kiosks. Computer-based training programs.	In environments where equipment must stand up to liquids and other contaminants: restaurants, factories, and hospitals.	Suitable for outdoor and industry use.	Suitable for Food Industry application.	Suitable for outdoor use.

Benefits offered by the technology

Regardless of the industry or application, the essential benefits of touchscreen technology remain unchanged. They:

- Enable people to use computers instantly, without any training whatsoever;
- Reduce operator errors significantly. Users make their selections from clearly defined menus;
- Eliminate keyboards and mice which many users find intimidating and cumbersome;
- Are rugged enough to stand up to harsh environments where keyboards and mice often get damaged;
- Provide fast access to all types of digital media, with no text-bound interface getting in the way;
- Facilitate multilingualism in dedicated applications;
- Ensure that no space on the desktop or elsewhere is wasted as the input device is integrated into the monitor.

Head-mounted displays and Shutterglasses

Head-mounted displays

Head-mounted displays (HMD's) are portable, wearable monitors. Stereoscopic vision is achieved via the combination of two little LCD or CRT monitors, one for each eye. In addition, these devices may include a headtracker which either replaces or complements the use of keyboard, mouse or joystick input by tracking the movements of the user's head. Stereo-headphones or multiple loudspeakers may be used to create mood or deliver information.[87]

HMD's are like a set of heavy sunglasses that a computer can write over. Typical augmented reality (AR) systems overlay transparent or semi-transparent computer graphics on top of the real world, and constantly align the graphics with the user's view direction and head position.

The fundamental difference between and VR and AR displays is most noticeable when they are switched off. With VR the screen is black. When AR is turned off the viewing glass becomes transparent. AR provides a noticeable contrast between the real and virtual worlds, and will continue to do so until photorealistic, immersive virtual reality becomes commonplace. The challenge with AR displays is to fix the artificial graphics in relation to positions in the real world, so that the motion of the user's head does not make the graphics 'swim'. This is done by tracking head motion and transforming the graphics to compensate. Poorly tracking the motion can induce feelings similar to seasickness. Slow motion analysis and graphics pipeline delays may be compensated for by estimating the user's motion with a Kalman Filter, which anticipates the user's future movements based on current movements, and compensates for these accordingly.

HMD's are often classified according to whether they are occluded or see-through displays. Occluded (or inclusive) displays make visible to the user only the image produced by the display, while see-through (or augmented vision) displays allow the viewer to see both the image produced by the display and the surrounding real environment. HMD's can be classified according to the number of images presented and to which eye-

87 See the visit to Glasgow School of Art's Digital Design Studio, below, for an account of such a multi-speaker set-up.

screen they are sent. There are three classes currently in use. Monocular HMD's present a single image to one eye, biocular ones deliver a single image to both eyes, and binocular HMD's display different images to each eye. Only the last class of HMD can be used for the presentation of truly stereoscopic image.

Head-mounted displays generally project virtual images. Specifically, a see-through (or augmented vision) helmet mounted display presents a virtual image which is perceived as being in the same place as a background scene. Viewing a real image requires an image plane or viewing screen and defeats the purpose of the transparent display. The fundamental difference between a real and a virtual image is that a real image can be viewed at an accessible plane in space, with a screen of some sort, while a virtual image can not.

Current limitations which have been recognised and should be overcome in the near future are:

- inadequate display update rates;
- equipment weight leading to user discomfort;
- inability to provide high resolution with a broad field of view.

Liquid Crystal Shutterglasses

Shutterglasses are glasses which transform the way the user sees the image on a standard monitor. They are used together with a normal CRT monitor, but normally not with LCD ones. The two images required for stereoscopic vision are displayed on the standard monitor in turns. The image for the left eye is displayed for some fraction of a second, after that the image for the right eye appears for the same duration of time and so on. The job of the glasses is to prevent the left eye from seeing the image dedicated to the right eye and vice versa. To achieve the illusion of 3D imaging from a standard display the shutters on the glasses open and close at a rate faster than the user is able to perceive.

Applications in Augmented Reality

Displays that interactively blend 3D virtual objects with the real world around the user have tremendous potential to help real-world tasks in navigation, the maintenance and assembly of complex equipment, medical visualisation, and entertainment. For example, in the future a motorist wearing a pair of 'magic glasses' might look under the bonnet of her car and see 3D animations and directions superimposed on her engine to guide her in repairing the system.

Applications in Human Tracking

While computers today are good at producing large output bandwidth, input bandwidth on the user's actions is usually extremely limited: keyboard clicks, mouse movements, and occasionally speech. Accurate tracking of the user's position and orientation is an enabling technology for more sophisticated future human-computer interfaces. These trackers will have to be accurate, long range, minimally encumbering, and have to work in many different environments, including weather-susceptible locations. Hybrid combinations of different technologies will be key in this respect.

Applications in Virtual Environments

Immersive systems using head-mounted displays and large head-tracked stereo display, offer a more natural and intuitive interface for certain applications, including training, simulation, and prototyping.

B. Auditory technologies

Speech-actuated control: Speech Input Systems

Speech input (or speech recognition) systems allow spoken utterances to serve as input to a computer. When the system 'hears' a sound it recognises, it sends a pre-defined character or group of characters to the computer which accepts the input just as if it had been typed on the keyboard.

Speech input systems can be useful for people who have physical disabilities preventing them from using the keyboard. Their use may reduce cases of repetitive strain injury and ganglia occurring as a result of long-term, intensive keyboard and/or mouse use. For those with severe disabilities or those performing complex tasks in constrained environments mouthsticks, switches and optical headpointers may offer alternative input devices.[88]

Although speech recognition software has been in development for several decades, effective, commercially available products have only appeared in the last few years. Speech recognition is a function available in simplified Chinese, English and Japanese language versions of *Microsoft Office XP*, and speech recognition techniques can be used to dictate text into any *Office* program. Users can improve their productivity by using voice commands to select menu, toolbar, and dialog box options.

Speech recognition is not yet designed for completely hands-free operation. In 2003 the best results can be achieved if a combination of voice and mouse/keyboard is used. The main drawback to the use of speech recognition to drive public access terminals is that for anything but the smallest range of commands voice recognition modules must be 'trained' to recognise the particular voice of individual users.

C. Motion tracking technologies

The Eye Mouse

What is an eye mouse?

Computers are generally controlled by hand, using a keyboard, a mouse or a trackball. Many people who are unable to use their hands can feel disenfranchised by their inability to utilise this type of equipment. The eye mouse can offer severely disabled people a way to control a computer simply by moving their eyes or head, controlling the cursor on the screen and using computers as able-bodied users do.

How does an eye mouse work?

The eye mouse is an ocular prosthetic that allows the cursor to be positioned by looking and hands-free pointing. Two methods have been developed for the eye mouse:

- Video-based: The binocular eye-tracker has been configured and calibrated to send x and y co-ordinates of the eye position to the PC, locating the point on the screen at which the person is looking. Software on the PC takes this information and sends it to the operating system as a mouse signal, and the x, y co-ordinates determine the

88 It goes without saying that speech input systems can hold great advantages for all categories of users, from the able-bodied to the seriously disabled.

screen cursor position. The selection, emulating the pressing of a mouse button, is achieved by the software detecting when the eye is held still for half a second or the user winks. This differs from natural eye blink and the eye tracker will not treat blinking as a valid signal. The use of a binocular system allows the closure of the right and left eyes to emulate pushing the right and left mouse buttons respectively.

- Electrode interface: The eyes act like a dipole in space and create an electrochemical field in the surrounding extra cellular fluid. With an upward look, the upper parts of the eyes become more positively charged than the lower parts. The inverse is true if the person looks down. If the person looks right, the region to the right of the eyes becomes more positive, and vice versa if the person looks left. These differences around the eyes can be transduced by scalp electrodes, and detected by an instrumentation amplifier.

Where is the eye mouse used?

Besides helping people with disabilities control computers, there are appealing eye mouse uses for people without disabilities. The novel use of the eye in conjunction with the eye mouse optimises the interaction between man and machine. It enables the user to utilise both the keyboard and the mouse simultaneously, allowing greater efficiency and enhancing the human interactions with the computer. In addition, the eye mouse can be used in the development and design of graphical user interfaces or in the analysis of human eye-response to still and motion images, such as printed advertisements and television commercials. The eye mouse can be usefully employed in advertising, using critical eye-gaze information to investigate which advertisements attract more intended customers and on what information viewers are making their buy or no-buy decisions. Clients may find that the current format of an advertisement places a critical piece of information in a place that is overlooked, sacrificing potential sales. It enables the agencies to create better, more effective advertisements for their audience.

The eye mouse enables software developers to make better use of interfaces and create easier-to-use applications. It allows them to discover how the user interacts visually with their product. Application analysis is good for determining what makes a successful graphical user interface. Knowing where a person looks during various use phases of an application allows developers to design better GUI's to accommodate differing work modes. A possibility for future GUI designs is an intelligent interface that detects the type of work mode the user is in and automatically changes its layout to suit that type of work.

In addition, it provides a revolutionary technology to the PC gaming industry. For the first time, games are able to utilise two interfaces simultaneously in both the hands and in the eyes. It can be applied to virtual reality and could act as a tool for tracking the position of an object such as a head or a hand.

Current scope and future development of the technology

There are currently a significant number of eye mouse products on the market. Every system and product has the ultimate goal of replacing the traditional hand-controlled mouse. The 'mouse' is based around some intuitive standards and any device which could replace it must follow these same principles.

For thousands of people, an extreme disability such as severe palsy or sclerosis deprives them of the use of their limbs and facial muscles. Approximately 30,000 people are currently afflicted with amyotrophic lateral sclerosis, with a further 5,000 cases reported annually in the U.S. For those who are unable to control a standard mouse, the benefits

of the eye mouse are extremely pertinent. The future development of the eye mouse will not only empower the handicapped, but will also become a powerful tool for advertising and GUI development. Researchers have used the device to associate pupil dilation with action and emotion.

D. Technologies combining several senses

Brain-actuated control

This technology combines eye-movement, facial muscle, and brain wave bio-potentials detected at the user's forehead to generate computer input useful for a variety of tasks and recreations.

The forehead is a convenient, non-invasive measuring site, rich in a variety of bio-potentials. Signals detected by sensors in a headband are sent to an interface box containing a bio-amplifier and signal processor. The interface box connects to the computer's serial port. The forehead signals are amplified, digitised and translated by a decoding algorithm into multiple command signals, creating an efficient, intuitive and easily learned hands-free control interface.

Three different types (or channels) of control signals are derived from the forehead signals. The lowest frequency channel is called the ElectroOculoGraphic or EOG signal. This is a frequency region of the forehead bio-potential that is responsive primarily to eye movements. The EOG signal is typically used to detect left and right eye motion. This signal can be mapped to left and right cursor motion or on/off switch control.

The second type of control signal is called the ElectroEncephaloGraphic or EEG signal. This region is subdivided into frequency bands called in some cases 'Brainfingers'. These frequencies reflect internal brainwave activity as well as subtle facial muscle activity. A wide range of facial muscles can affect these frequency bands, and users typically learn control of their Brainfingers first through subtle tensing and relaxing of various muscles including forehead, eye and jaw muscles. After a little experience with the *Cyberlink* system, most users begin to experiment with more efficient, internal brain-based control methods. Since this frequency region is sensitive to both mental and muscular signals it is called the 'BrainBody' signal. Brainfinger control is continuous or analogue and is typically used for tasks such as control of vertical or horizontal cursor movement. For example, one Brainfinger may be used to control vertical movement while a second Brainfinger (or some other signal channel) is used to control horizontal movement.

The third channel is called the ElectroMyoGraphic or EMG signal. This signal primarily reflects facial muscle activity. It is typically used for discrete on/off control of program commands, switch closures, keyboard commands, and the functions of the left and right mouse buttons. Specific facial and eye movement gestures can be discriminated by software means, and mapped to separate mouse, keyboard, and program functions. For individuals with limited control of their facial muscles, the software can be formatted to use BrainBody or EOG inputs (instead of EMG) to activate switch closures and mouse button clicks.

These brain-actuated control systems provide an intuitive, direct, easily learned, hands-free, and language-independent control interface. They represent a cutting-edge technological achievement in the user-computer interface, making possible new computer control methods to empower the disabled and all users of future technology.

E. Wearable computers

What is a wearable computer?

The term 'wearable computer' was introduced by researchers from Carnegie Mellon University in 1991, although the idea for augmenting human senses goes back to the 17th Century. According to Starner, 'wearable computing pursues an interface ideal of a continuously worn, intelligent assistant that augments memory, intellect, creativity, communication, and physical senses and abilities.' The term 'wearable' should be clearly distinguished from 'portable'. Its main characteristic is not that it is easy to carry, but offers easy communication with the user.

Specially designed wearable systems consisting of a wearable computer, HMD and an input device are used by Boeing aircraft mechanics, with the system providing them with the most up-to-date version of technical manuals. The system is intuitive and portable, although blocked peripheral vision was a common complaint amongst the users.

The development of this field could result in even more unexpected input and output devices. One area of concern is the power supply for the system. Wearable computing is still a relatively young field of information technologies, and research has not yet matured sufficiently to fulfil the idea behind it to full potential. The basic aim is to create wearable devices which require minimal amount of interaction on the user's part. This idea would realise the vision of ubiquitous computing field perfectly. Wearable computers could facilitate museum visitors in orientation and study of the collections, starting from consulting a guide and ending with possibilities for immersion in an augmented reality environment. Experts still feel that the technology is not ready, and this prevents wider use.

Human Interfaces Technology and the Heritage Sector

Brief Background

This section presents three wholly different types of interface application. One case study investigates touchscreen technology at the J. Paul Getty Museum in California, another looks at multimedia presentation of fragile precious items at the Philadelphia Museum of Art, and yet another on the use of portable guides in the Kulturen museum in Lund, Sweden. This diversity in uses and approaches is natural for such a broad area where 'recipe books' do not yet exist.

Case Studies

Case Study I – J. Paul Getty Museum [89]

The J. Paul Getty Museum, founded in 1953 in a villa in Malibu, California, moved

89 This case study is based upon materials from the Web pages of the J. Paul Getty Museum (http://www.getty.edu/museum/) and Elo TouchSystems Inc. (http://www.elotouch.com/), both sites visited on 07/01/2003.

into the new Getty Centre in 1997. The museum collects art in seven distinct areas: Greek and Roman antiquities, European paintings, drawings, manuscripts, sculpture, decorative arts, and European and American photographs. The museum's goal is to make the collection meaningful and attractive to a broad audience by presenting and interpreting the collection through educational programs, special exhibitions, publications, conservation, and research.

In keeping with its modern image, the J. Paul Getty Museum aims at presentation, that allow visitors to see three different sets of materials: collections which are not currently on display, background information on current exhibits and interviews with artists. In addition to this, the information technology allows users to create their own personalised tour of the gallery.

A software development company specialising in network solutions, **ThunderWave Inc**[90], assisted the museum in its mission, creating the *ArtAccess System* of 28 interactive kiosks. The core HCI component for each of the kiosks is an *Entuitive* touchmonitors produced by **Elo TouchSystems Inc**.[91].

The *ArtAccess System* involves *TWIST* (ThunderWave Interactive Streaming Technology), a *Windows NT* ODBC-compliant system that allows content to be easily added to or removed from the system. 'A fiber-optic cable provides each kiosk with its own hotline to the server, so there's no bandwidth sharing among the kiosks,' explains Yechiam Halevy, president of **ThunderWave**. There are currently five *ArtAccess* rooms and 22 touch-based workstations which act as both educational resource and a reference point to visitors. Each workstation is focused on the same interface, so visitors can access the same information from each room. Six additional kiosks are used for editing, authoring and demonstrations.

'Each kiosk puts images, videos, voice and text about 5,000 objects and 1,200 artists literally at visitors` fingertips,' says Ken Hamma, assistant director for collections information at the museum and project director for the museum's Website. 'ArtAccess lets users search the collection by artist's name, subject, era, gender and nationality. With one tap on the touchscreen, a visitor can watch a video about how the ancient Greeks created a vase and zoom in to see a grain of the clay, or print a customised map that shows the location of all the vases in the museum.'

According to Hamma, the already exhaustive content will grow further to reflect new acquisitions, rotating exhibitions and, in a few years, the reopening the Getty Villa which will house the collection of Greek and Roman antiquities currently only partially on display in the Museum at the Getty Centre.

Since the museum opened, about 16 per cent of all visitors have used the system; between 700 and 1,000 people each day. 'We are certainly pleased with the performance of Elo's touchscreens,' says Hamma, They are durable and function well under such rigorous demands.' The key benefits for this collection are seen in the intuitive user interface, increased design opportunities, robust system for both employee and visitor use, simplification of complex technology, reliable and consistent service, accurate activation by finger, soft stylus or gloved hand.

90 Now trading as BeyondGuide Inc, http://www.beyondguide.com/
91 http://www.elotouch.com/

Case Study II – Philadelphia Museum of Art[92]

The exhibition 'The Arts of Hon'ami Koetsu, Japanese Renaissance Master' was held at the Philadelphia Museum of Art (July 29 – October 29, 2000). The purpose of this exhibition was to educate and present the beauty of the artist's calligraphy, lacquer ware and ceramics. The exhibition featured more than 100 objects.

Traditional Japanese art was created not just to be observed at a distance, but also to be touched. In the modern museum setting visitors do not have the opportunity to handle the objects they see and this prevents them from gaining the originally intended experiences. This is a common problem for museums, libraries and archives because all store precious items under restricted access.

Is there yet a way that visitors could touch such an object? How can new technologies help in this? This exhibition gave an interesting answer, presenting in a novel way a precious handscroll and a tea bowl created in the 17th Century. Two interactive displays were designed to simulate handling of these objects where tactile investigation is an integral part of the experience. Specialised multi-media programs were developed by the International Academy of Media Arts and Sciences (IAMAS). Thus computer technology helped visitors to feel what it is like to hold a tea bowl or to roll a handscroll and to hear the poetry that is presented on it. These objects were not the only presented in the exhibition. Visitors could grasp some of the cultural background, possibly getting a better idea of the culture and atmosphere of Japan in the early 17th Century.

People involved in the project included curator Felice Fischer and Yasuhito Nagahara, graphic designer at the International Academy of Media Arts and Sciences in Gifu. The curator needed to get across most of these experiences based on touching the objects without harming them. Two of the objects in the exhibition were chosen for this purpose, the handscroll of Poetry over Design of Cranes ('Tsuru shita-e wakakan') and the black Raku ware tea bowl 'Shichiri'.

The scroll is stored at the Kyoto national museum. It was written in ink with gold and silver on paper, and is about 34 x 1360 cm in size. Such a scroll was clearly designed to be viewed in short episodes, section by section. The contemporary reader would not look at it from a distance but close up, handling it and moving through past, present, and future.

The reproduction of the handscroll maintained its original form and size with dowels in both ends, as a rolled up scroll of paper. In fact the paper was blank and could be replaced, and the image was projected by a device attached to a *PowerMac G4* over a glass which was in turn placed above the blank paper the visitors touched. While a visitor investigated the roll, he was provided with different options for the content being displayed: the calligraphic text, the paintings, or both. The role of the dowels was crucial – they contained sensors reporting what was happening with the scroll, respectively what had to be projected. At the same time, the visitor could hear the recitation of the poetry.

In the traditional Japanese tea ceremony, tea bowls are customarily touched and admired. The Black Raku Tea bowl, named 'Shichiri', from the Gotoh Museum (height: 8.6 cm, diameter: 12.2 cm, diameter of foot: 5.2 cm) was chosen as the second object for the innovative display.

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92 This case study is based upon materials from the Web pages of Philadelphia Museum of Art (http://www.philamuseum.org/) and IAMAS in Gifu, Japan (http://www.iamas.ac.jp) both sites visited on 08/01/2003.

The bowl display was executed in a different manner to that of the scroll, since the object is significantly different in its physical appearance and shape. Three-dimensional data were obtained via CAT scans of the original. Based on the obtained data, a resin teabowl was made, hardened through irradiation by ultra-violet rays. This surrogate gave the feeling one would have touching the original, and matching the real object in size, weight and texture. Thus the inside bottom or the underside of the foot could observed where they would otherwise be visible only if the teabowl was upended manually.

The organisers and developers of the multimedia tools for the exhibition were pleased with the results. Visitors expressed satisfaction in gaining a unique experience. Partial support for preparation of the specialised displays was gained by grants from the Juroku Bank, Ltd., the Juroku Bank Regional of Promotion Foundation, and Itochu International. Donations of equipment were received from **Sony Corp** USA and **MicroWarehouse**.

Case Study III – Kulturen[93]

Kulturen is the world's second-oldest open-air museum. It is situated in Lund in southern Sweden in a park with about forty houses and more than two million artefacts from all over the world. The historic buildings portray everyday lives from the Middle Ages until the present.

In 1997, Kulturen applied for and received funding to develop the use of information technologies as a natural part of the museum's work, internal and external. Most of the money was spent to build the internal infrastructure. Together with the University Museum of Lund, the staff at Kulturen took part in developing a hand held museum guide called *Saxo*, a groundbreaking system which involved the use of the **Apple** *Newton*[94] portable computer. The idea was to build a museum guide that could be offered to the visitors via a PDA device, and which was flexible enough to serve the widely differing needs of the collection.

There were several impetuses for starting work on the project, chief among which was to offer a device guiding foreign visitors and other users with special needs. This device should give the visitor an opportunity to see the exhibitions independently, but at the same time complementing their experiences with additional information. The *Newton* device was used as a guide, stored with more information than there was displayed in the museum. As Sebastian Goksör, Systems Administrator at the museum, explains: 'The curators wanted clean exhibitions, with less interruptive texts.' Therefore, the role of the device was to fill in the gaps between the detailed exhibits and their corresponding descriptions. The need was to serve visitors with special needs or foreign languages and to offer substantially richer information on the collection.

When these aims were clarified, the staff at Kulturen searched for a handheld device suitable for the project's needs with audio and maximum storage capacity for a number of languages. The devices had removable memory sticks, which therefore offered the possibility of different programs for each use. Maps of some exhibitions, written and spoken

93 This case study is based on a questionnaire completed in January 2003 by Sebastian Goksör, Systems Administrator at the museum. Subsequent information comes from the Kulturen Website, http://www.kulturen.com

94 The Apple Newton was the earliest Personal Digital Assistant (PDA). Released in 1993, the first Newtons had a notable weakness – poor handwriting recognition. Newton lost its lead in the emerging PDA market to the newly introduced Palm Pilot in 1996. The Palm Pilot and other subsequent PDA's were smaller, cheaper, and enjoyed higher sales figures. Apple officially discontinued the Newton and all related products in February 1998.

text were then developed in various languages, including Swedish, English and German, in order to serve a range of users from different countries.

In the beginning it was hoped that there would be no limit to the number of commercial programs available for the device and that the visitors would enjoy using it as much as the museum's staff did. As the project progressed these hopes did not materialise, and a number of problems arose as a result.

Who would be responsible for the Newton's daily care and technical problems? Who would be able to produce new programs, and who should pay for it? It was also discovered that the Newton was incapable of matching the performance demands of the project. At this point Kulturen decided to put the project development on hold, with the option to continue work in the future when the technology is better developed and less expensive. The *Saxo Newton* project still runs acceptably, with 10-15 devices in operation. However, the devices are no longer openly available in the museum.

The University museum has continued to develop the idea. Alternative technologies under study are the **Compaq** *Ipaq, Bluetooth/IR,* mobile telephones, and an on-site server with material delivered in the form of HTML Webpages.

In one sense, the *Saxo* project demonstrates a number of problems which an organisation can meet trying to offer a novel service with modern devices, namely the unreliability of suppliers and the difficulties inherent in developing from an immature technology.

Sebastian Goksör reports: 'I think there was a belief that everything was going to be alright and that technical problems more or less were going to self-solve when they occurred. But the **Apple**-supported part of the team did not actually spend that much time solving these minor problems we ran into, giving the rest of the team a bad input.' This caused delays and frustration, as work on the project ground to a standstill again and again. 'The curators could not go on coming to meetings in the group to discuss the same problems and matters as in the last three or four meetings, problems that everybody thought the technicians should have had solved long ago.'

The curators were ready to try to develop the programs themselves, but this was not easy to do. The design of the programs was felt to be dull and unengaging and the PDA's had a tendency to collapse while in use or when the batteries were being recharged. The staff in the museum which dealt with the visitors and faulty equipment on a daily basis began to dislike the whole project.

Goksör explained that: 'we learned that we should have set the aim by ourselves before we joined the project. Also, to make the project run smoothly, we should have been sure that we could deal with all aspects of technical problems by ourselves, within our organisation. Everything, from recharging batteries to producing and change the programs. We also found that all parts of our organisation who were going to deal with the devices must be involved in the project, understanding all different aspects and problems that could emerge.' External consultants did not appear to be helpful enough with the frequent technical problems.

Such experience is essential, especially when cultural institutions are trying to investigate new technologies, and staff at Kulturen has held discussions with specialists from the Museum of Sports in Malmö, giving advice and contacts when they developed a similar **Bluetooth-Ipaq** HTML program.

Case Study IV – The Stafford Past Track project[95]

The Stafford Past Track project is an initiative of Staffordshire Arts & Museum Service (AMS), and was a multi-partner project led by two services within the Staffordshire County Council in the English Midlands. The aim was to improve access to the Council's holdings of local history-related visual material, including texts, photographs, prints, paintings and audio-visual material. Improved access to these collections was the project's key goal and chief selling point. These are large collections, held at a number of sites across the county and, prior to the project, this material was available for viewing by appointment only. Digitisation enabled the Arts & Museum Service to pool these collections and integrate them with other private and publicly-held collections into a single database.

When work began on the Past Track project in 1999, it was initially hoped that the system would be made available via the Internet. The technology available at the time could not satisfactorily handle interactive mapping on the Web and standalone touch-screen systems were used instead. It was quickly realised that maintenance of large numbers of standalone units could not be sustained and, as mapping technology became more affordable, Web-delivery became a viable proposition. It has massively increased the accessibility of the material.

Due to the success of the standalone elements of the Past Track project, subsequent New Opportunities Fund (NOF) support was secured to extend the system. The AMS sought and received a substantial amount of external funding and the second stage of the project has been a collaborative effort with the County Council Education Department's IT unit. This unit has helped develop the online technology.

A user accessing the project homepage is offered a choice of paths through the material via interactive Ordnance Survey maps, predefined themes or an Advanced Search function which is used to retrieve specific objects or records. The map search function uses a *Zoomify* image plug-in for Web browsers, which enables site users to zoom in and examine areas of an image at a larger scale through a process of image streaming. An interactive map of the county invites the user to click on an area of interest. The user can then zoom in on that area progressively. Areas of the map where records are available are shaded in yellow and areas with a higher density of records are shaded in pink. Each record is associated with a particular geographical location and when users have selected their areas of interest they click on a button to display all of the records that originate in the vicinity. While viewing the material, users can create their own album of resources to which they can add their own notes, thus enhancing the interactivity of the venture and making the project more actively engaging.

The technology was selected through site visits and discussions with users and producers of similar systems. The AMS needed a system which was simple to use for a wide range of user groups, reliable and relatively easy to maintain and which met Disability Discrimination Act requirements for accessibility. The obstacles overcome tended to be mainly technical. The Geographical Information System (GIS) , the transfer of digitised historic mapping and the conversion of existing database information were all time-consuming and challenging. One anticipated risk was the reliability of equipment and soft-

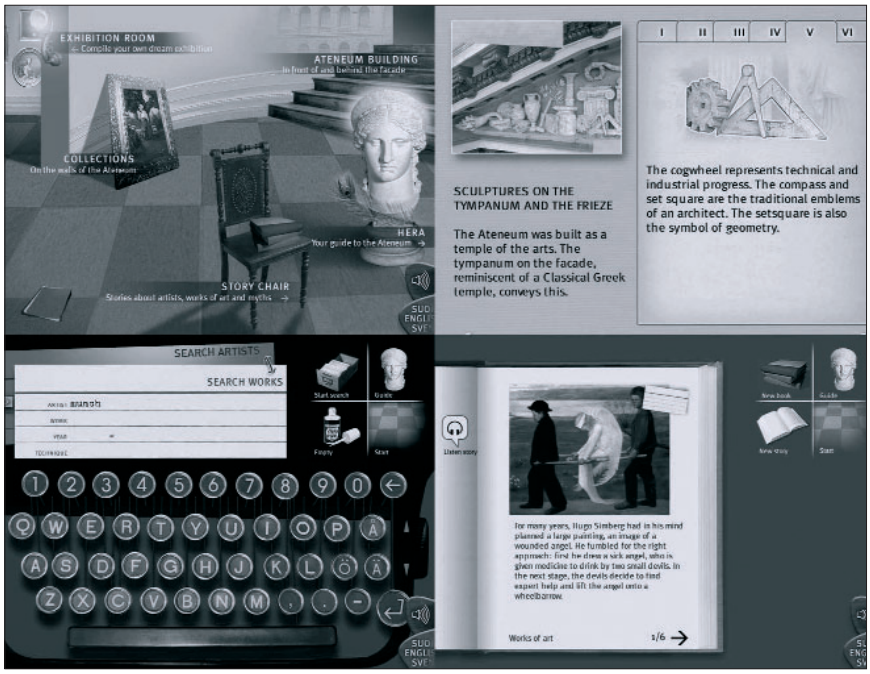
95 This case study is based on a questionnaire completed by Chris Copp, Museums Officer at the Staffordshire Arts & Museum Service, and on information from the project's Website (http://www.staffspasttrack.org.uk/), accessed during January 2003.

ware, though after thorough planning and research the AMS hit upon what it considers to be a suitably reliable system. Copyright issues posed a potential pitfall, and to avoid the difficulties that might have arisen as a result, an efficient system for copyright clearance and protection of owner/creator rights was established.

The project has been a success, with all project aims being met within the set timescale and budget. Evaluation has demonstrated high user satisfaction and continuing demand for the system's expansion. The anticipated benefits have been achieved. Resources tapped by the AMS during development included staff skills and expertise, existing networks of museums, libraries, archives and local history groups, public buildings in which the systems were housed, and the use of volunteer staff to carry out a variety of tasks. In addition to this, two temporary members of staff were employed to carry out the digitisation and database completion. Specialised IT equipment and software was introduced. Historic Mapping and Sites and Monuments records from the District Council were consulted, together with the resources and knowledge of local history groups and individuals.

Case Study V – The Finnish National Gallery[96]

The Ateneum Art Museum, a unit of the Finnish National Gallery, was opened at 1887 with the idea of bringing together the national arts and crafts communities.[97] The Ateneum had two initial purposes, namely housing the collections and the Drawing School of the Finnish Art Society in one half, the School of Applied Art and the collec-



In Touch with the Ateneum: A montage of screenshots of the user interface

96 This case study is based on a questionnaire completed in February 2003 by Riikka Haapalainen, Researcher at the gallery's Art Museum Development department. Subsequent information comes from the gallery's Website, http://www.fng.fi

97 http://www.fng.fi/fng/html4/en/ateneum/default.htm

tions and offices of the Finnish Society of Crafts and Design in the other. Athena, the goddess of arts and crafts, was a natural patron for the museum.

Today, the Ateneum's role is expanding and becoming increasingly diverse. In addition to housing the Museum of Finnish Art, it now accommodates the Central Art Archives, a photography collection, a press archive, a specialist art library and Conservation and Education units. The last of these has the responsibility for workshops, the auditorium, and general educational projects.

The starting point for the program called *In Touch with the Ateneum* was the desire to create a multimedia tool which could offer different insights into the visual arts. This should be usable for as many museum visitors as possible, regardless of their skills, backgrounds and levels of computer literacy. The purpose of the team was to build a multimedia program that was content-rich, multi-modal, accessible, conformant with the Design for All principles, and which supported different kinds of learning styles and information. The team included two principal members who created the core content, one graphic designer, one sound designer, one programmer and one accessibility consultant.

Multimedia kiosks were chosen for the delivery of the programme, each of which featured magnifying glasses for the partially sighted, headphones and an induction loop for those with hearing impairments, and a 'pointing stick' for people with manual dexterity difficulties. The touchscreen interface, explained Riikka Haapalainen, Researcher at the gallery's Art Museum Development department, is easy to use but still has a sense of adventure. Strong emphasis was placed on accessibility and enjoyment for all users.

To begin with, the team conducted a small-scale survey on the questions, comments and problems of the museum's visitors. Guides and guards working in the exhibition halls were asked to keep a diary on their everyday interactions with visitors. This data supported the planning process and created a loose structure for the content of the program. The multimedia program itself was compiled using **Macromedia's** *Director* program. To increase user-friendliness, the content was conveyed through various senses.

For example, the visually impaired may find the sound facilities helpful, and the texts featured in the program could be listened to using headphones. Other sounds support and enliven the visual features and create the right atmosphere for storytelling. Special attention was paid in the graphic design to keeping the program's visual appearance calm and clear. To ensure easy use for everyone, the elements were designed to stand well out from the background, a sufficiently large and discernible typeface was used, and the program proceeded in a logical fashion. The texts were written simply, observing the principles of easy-to-read language.

Special attention was paid to present on-going work on the project, including sketches and ideas from various personnel of the Finnish National Gallery and Ateneum Art Museum. This helped people across the entire organisation realise the importance and value of such input, at least in theory. In addition, just before the program was launched the team working on it arranged an internal briefing on the new multimedia kiosks and conducted a small training session for the museum guards about the content and use of the program, including what to do and who to inform in the event of the computer crashing.

The major obstacles met during the development and implementation of the program were how to organise continuous content management and development, activities that required uninterrupted budgeting, and the general maintenance of the program. Even after the program had been presented to the public, it still needed updating with improvements and new content. This clearly illustrated the fact that major programs are likely to require an organisation-wide commitment for many years.

According to Haapalainen, the implementation has not been as successful as was expected, perhaps due to organisational upheavals in the gallery which took place while the program was in development, leading to difficulties with workflow and communications between departments. The anticipated benefits, however, were achieved among the museum visitors, and their feedback, particularly that concerning the interfaces and content delivery, has been extremely positive.

Amongst the risks, which were to some extent anticipated, were the lack of sufficient and continuous funding. This caused problems due to the relatively high expenses incurred in creating multimedia applications and simultaneously developing innovative and accessible features.

The organisational changes, which have put the existence and development of the program at risk, were not anticipated to have the consequences they did. Another difficulty has been the grater number of computer break downs than forecast taking longer to fix than anticipated.

Case Study Case Study VI – The SHAPE Project[98]

Nottingham Castle is one of Nottingham, England's most popular tourist destinations. In July 2002, the castle invited its visitors to combine their exploration of it with testing some new and innovative computer displays, designed to complement the exploration and enchancing their understanding of this historical venue.

The experiment took the form of a quest or 'history hunt', made possible with the research and development of the SHAPE project, a part of the European Union's *Disappearing Computer Initiative*.[99] SHAPE, or *Situating Hybrid Assemblies in Public Environments*, is a European Commission-funded project concerned with using hybrid reality and embedded or subsumed forms of computing to enhance interpersonal interaction in public places. Cultural heritage institutions such as museums and galleries, with their large and diverse visitor communities, are natural candidates for the development, testing and application of these new technologies.

The SHAPE consortium has four partners: the Centre for User-Oriented IT-Design at the Royal Institute of Technology, Stockholm, the Mixed Reality Laboratory at the University of Nottingham, the Work Interaction and Technology Research Group at King's College London, and the Interaction Design Centre, University of Limerick in Ireland. Several museums from across Europe[100] have taken part in the project, providing the conditions for three 'Living Exhibitions' which demonstrate the SHAPE mixed-reality installations to ordinary visitors.

The technology used in the Living Exhibitions had to offer an environment which would mix the physical setting with digital information for the purpose of enhancing the interaction of the visitor, both with the exhibition, providing numerous and innovative learning channels, and with visitors by improving collaborative understanding, and contributing to more enjoyable shared experiences.

The project team developed a hybrid reality scenario based on archaeology, offering the educational and interactive benefit that participants feel part of a special community

98 This case study is based upon material from the Webpages of the SHAPE project, 'Situating Hybrid Assemblies in Public Environments', http://www.shape-dc.org/ visited on 28/01/03.
99 http://www.disappearing-computer.net/
100 The Technical Museum in Stockholm, the Ducal Palace at Nottingham Castle, and the Hunt Museum in Limerick.

of practice. The physical discovery and exploration of artefacts is attractive, and the collaborations and discussions between participants are essential characteristics of the archaeological experience, together with the excitement felt when an object is uncovered. This excitement comes not only from the initial excavation of objects, but also from a sense of 'intimate' discovery of artefacts from the past. As it is usually not possible for the general public to touch or handle such rare objects, the project's challenge was to determine how best to simulate these aspects using information technology.

The project team had the initial idea of using archaeology as a collaborative quest activity in order to enhance the visitor experience in the actual physical setting of the museum, allowing a game-like atmosphere to emerge. In Nottingham Castle, visitors explored the castle grounds looking for clues and evidence of the past. These clues appeared as pieces of paper and were used to interact with different types of displays providing the users with more information. These include:

- Underground torches, used to trigger atmospheric sounds and to 'explore' events that occurred in the immediate vicinity;
- A 'storytent', a tent-shaped display, comparable to a virtual reality CAVE. Visitors sit inside and immerse themselves in three-dimensional scenes from the past;
- A 'sandpit', a floor-projection which allows users to sift through simulated sand and uncover images of the castle's history.

The experiment was very popular with visitors, and the project partners now hope to develop the hybrid reality archaeological scenario further with the inclusion of hybrid physical-digital objects incorporating embedded RFID smart tags, thus adding another layer of interactivity and collaboration to the learning and discovery experience.

Scenarios

Scenario I – Planning Museum Exhibitions for Children

A museum is looking for different ways to make its collections more engaging for younger visitors. It offers several rooms for play and study with various sections, including:

- A giant construction table where different mechanisms can be put together. Parts of the models are taken from the museum collection, and children can see them before beginning work on their own versions;
- A section for young builders, offering builder boards to construct objects which are big enough to play inside. As additional fun, children can use replicas of objects from the museum and discover their use under the guidance of a member of staff;
- A design studio where children can design their own models and inventions using traditional drafting tools. Replicas of costumes from the museum collections are available to the children;
- A traditional learning room.

The staff at the centre expressed satisfaction with the growing number of families visiting the museum with their children, but they believe that offering more computer technologies in the play centre would attract even greater interest. They decided to purchase a touchscreen for use specifically in the children's area. The museum already uses multimedia kiosks, but the multimedia program used in the museum halls is not appropriate for use by very young children. The mechanical construction area was chosen for the new service as it features the most references to the museum collection. The muse-

um's decision makers plan to invest in the development of a special presentation of the items used as examples in this part of the museum.

The museum ordered a specialised computer workstation to accompany the design studio. The program should offer number of shapes and textures, and give verified references to the costumes from different historical periods. To make it more enjoyable, the decision makers agreed to order a projection display which would show how the designed models work in natural size on a 3D model. Computers and specific edutainment software were purchased for the learning rooms, and the staff remained confident that varied computer experiences will attract more visitors and focus their learning on specific areas.

Scenario II – Estimating health risks for immersive VE

A museum is considering the use of an immersive virtual reality system in conjunction with head-mounted displays to demonstrate some aspects of mediaeval life. As part of the planning process, it is necessary to address and evaluate the potential health risks involved in such a project. Staff members who are providing visitors with instructions how to use the device are asked to explain possible health risks and to take notes on the visitors' feedback after using the system. Visitors are warned that people tend to remain in virtual environments even when experiencing discomfort, and to be sensible and seek advice or assistance at the first signs of unease.

A short questionnaire was drawn up along the following lines:

- Have you suffered from motion sickness-type symptoms? Key symptoms are nausea, hand-eye coordination errors, and disorientation.
- Have you experienced visual fatigue (eye strain), impaired vision, headache, muscle fatigue, particularly in your neck or back, or any other discomfort?
- Have you felt hot or sleepy due to the effort of supporting the HMD?

The museum staff hopes that collecting such data will contribute to the evaluation of use of the equipment and better advice to museum visitors, as well as helping them to draw up a set of guidelines on the safe use of immersive VR equipment for the future.

Benefits and Risks

Summary

The introduction of many new technologies is subject to a certain amount of public debate on their particular pros and cons. Many innovative devices are initially perceived as gadgets whose long-term uses are not clear or are considered applicable only to the amusement industries. This might lead to the public perception of some new devices as something interesting and fashionable, though expensive and with only a short lifespan.

In fact many of these devices can serve people in serious areas and reduce some of the unpleasant effects caused by the use of existing peripherals. For example, many of these new interfaces such as touchscreens lead to a more intuitive way of using computer equipment. The main benefits of new keyboards are seen in their improved ergonomics which lead to better posture, reduction of pain and resulting contentment for the user,

without having a negative effect on typing speed and error levels. Devices such as the eye mouse have a clear applicability for assisting disabled users in accessing new developments in technology.

The basic benefits of these new interaction devices lie in easier and less frustrating communication between users and their machines. In the cultural heritage sector, the possibility to 'see' and 'handle' objects virtually which are not otherwise available, and to complement the comprehension of an exhibition with additional background information organised as AR or VE, offers a multitude of new potential options. Such technology could be used for research purposes and in the long-distance study of collections, which may prove to be a significant plus point.

The effects of head-mounted display use in virtual environments may be of concern to heritage decision makers. HMD's have been reputed to cause both short-term psychological and long-term physiological problems. Experiments have been conducted which evaluate the differences between use of HMD's, standard desktop monitors, and projection screen displays. The results indicate that the highest levels of unpleasant symptoms are associated with the use of HMD's, although when participants are not static but have active control over their movement in the VE, they tend to feel better and report fewer problems.

It is reported that the use of HMD's may lead to physical difficulties such as posture problems because of the additional load on the body. Sometimes users start supporting the weight of the HMD using their hands. As is the case with many other types of peripheral, the intensive use of data gloves may lead to repetitive strain-type injures. One final note, which will be of particular relevance to organisations with significant numbers of physical visitors, is that public use of some of this expensive equipment may pose hygiene problems with the devices potentially becoming a home for bacteria transferred from user to user.

Companies producing new equipment are constantly updating or modifying their specifications. The physical discomforts caused by weight or unnatural and/or repetitive movements will most probably be overcome in the near future. The most serious health issues in the long run are those associated with physiological discomfort, sometimes known as 'simulator sickness', and hygiene issues raised by public use of the same device.

From an organisational point of view, the implementation of new equipment will have to be carried out in such a way that users have difficulty accessing or modifying the file-level content. Some organisations have had to allocate a staff member to minimise and repair the damage to the file system caused by visitors. In any case, the introduction of new equipment will necessitate a higher level of staff support, both for the visitors and users of this equipment.

Tabular Overview

Benefits	Risks	Device
New means for presentation of cultural content		
Possibility to study items virtually under restricted access regulations		Devices used in VE's
Easy interfaces, clear for computer illiterate or less-literate users		Touchscreens especially
Amusing technologies giving the sense of personal presence of the user in the environment		Digital camera input
Combine data input and output		Touchscreens, HMD's
Health benefits: better posture, less tension, reduction of pain		Keyboards
Facilitate disabled users		Eye mouse
	Hygiene issues for publicly used equipment	Especially HMD's, datagloves, wearables
	Immersion injuries	HMD's
	Physiological problems (simulator sickness symptoms)	Devices used in VE's
	Content safety issues caused by public access to content	
	Additional staff involvement	

Introducing the Technology

Policy and Organisational Framework

Among the fundamental challenges of modern information technology are the continual processes of change, and this is particularly valid in the discussion of new interfaces and interaction devices. Many of these devices offer increasingly intuitive use, but some require the acquisition of new skills and the comprehension of new metaphors and abstractions which were not used before. In addition attention should be paid to the potential need for training in the use of the new systems. Technology will only succeed if staff are motivated to make it a success.

This shifts the role of cultural sector institutions from presenting their specific subject domains knowledge, to complementing their educational function by developing a familiarity with the use of new equipment. In this setting of ongoing change, the decisions for purchasing new equipment become more and more complicated. Some questions which might help with the handling of this issue are given below:

- How and by whom is existing equipment currently used?
- What problems will investing in new equipment achieve? For example:

- replacing the current equipment with new brands and using it for the same tasks;
- improving the current practices;
- involving new technologies to present the holdings of the institution;
- facilitating the users in their learning or enjoyment;
- connecting to other institutions' resources;
- serving specific groups of users (disabled users, young, old);

- Can the long-term influence of the new equipment be measured? Would it fit in with the organisational vision for future development?
- Can this new setting save on costs and human effort?
- What skills will the staff have to acquire? How can these be provided?
- Is the technology helping to solve a problem? What new problems may arise?
  - Is the equipment stable enough for public use?
  - What maintenance is required? Would it need the special attention of staff members? What can be harmed by the visitors? (Files? The devices themselves?)

Existing Infrastructures Required

The technological infrastructure in the organisation definitely changes with the implementation of new human interfaces technology, requiring both hardware upgrades and the installation of new software or *drivers*. To move successfully through such changes, organisations should take care that they optimise the skills of the staff in a way that staff members feel able to work effectively in the technological environment. Management should ensure that the staff receive suitable training and assistance in those skills which are largely specific to the institution. For many cultural institutions the focus will be on providing services to the customers, and this appears currently to be a weak point.

What organisational structures make the technology appropriate?

New interfaces technologies are unlikely to require or lead to changes in organisational structures. It is normal for an implementation committee to be set up and all organisational staff responsible for the collection management are likely to be trained for the use of the new equipment. To a significant extent, the success of the introduction of new technologies is likely to depend on the standard of the technological personnel within the institution.

Management should conduct annual reviews of their staff skills with regard to potential obsolescence, and staff members should be provided with a report on the conclusions. Suggestions for further development of skills should be made at this stage. Staff job descriptions should reflect the specific requirements for skills and guidelines on good practice in using specialised equipment in day-to-day work should be formulated. Priorities should be clearly established and a training programme which targets the areas of greatest need should be developed.

Staffing levels and user base issues

Real-life experiences reported so far show that there could be a need to reallocate staff members to computer equipment which is available to the public and which is not

protected from deleting and replacing files. There may be cases in which staff will feel uncertain in offering guidance about equipment, probably the most common scenario would be the need to assist visitors, and the fear that expensive equipment could be damaged or broken. This means that staff training should be carried out carefully and dedicated staff will need to be active in offering similar assistance to visitors. Visitors must be aware of the potential side effects of immersive VE equipment, such as nausea, possible complications with cardiological pacemakers, and so on.

Appendices

Appendix I – HMD Suppliers and developers

Manufacturer	Product	Year	Price	Resolution	Field of view (degrees)	Binocular/ biocular
Canon	GT270	1999	<$1000	270k	n.a.	n.a.
Interactive Imaging Systems, Inc.	VFX-3D	2000	$1800	360k = 263*480*3	24°	biocular
Interactive Imaging Systems, Inc.	X-Viewer	2002	from $500	921k = 640*480*3	<40°	biocular
I-O Display Systems	i-glasses 3D	2000	$600NTSC $700PAL	180k = 263*230*3	n.a.	biocular
I-O Display Systems	i-glasses SVGA (2D)/ SVGA 3D	2001	$1200(2D) $1600(3D)	800x600x3	26° diag.	both
Olympus	Eye-Trek FMD-150W	2000-01		240k (16:9)	37.5°	binocular
Olympus	Eye-Trek FMD-700	2000		180k (360k virtual)	30°	binocular
Sony	Glasstron Lite PLM-A35	1999	$500	180k 267*225*3	30°	binocular
Sony	Glasstron PLM-S 700 (E)	1999	$2300	1.55MPix 832*624*3	28°	binocular

Checklist for choosing HMD's:
- what is the panel resolution?
- what display technology is used (LCD, CRT, other)?
- what are the weight and other physical dimensions of the device?
- is it binocular or biocular, and what is the type of the video signal?

Appendix II - Standards

The field of human interface technologies is relatively well standardised, and key international standards and technical requirements related to various aspects of human-computer interfaces are listed below:

Visual displays
ISO 13406: Ergonomic requirements for work with visual displays based on flat panels
ISO 18789: Ergonomic requirements and measurement techniques for electronic visual displays
ISO 9241: Ergonomic requirements for office work with visual display terminals.

Multimedia
IEC TR 61997: Guidelines for the user interfaces in multimedia equipment for general-purpose use
ISO 14915: Software ergonomics for multimedia user interfaces

Human-centred design
ISO 13407: Human-centred design processes for interactive systems
ISO TR 16982: Usability methods supporting human centred design
ISO TR 18529: Ergonomics of human-system interaction - Human-centred lifecycle process descriptions

Other standards
ISO/IEC 10741-1: Dialogue interaction - Cursor control for text editing
ISO/IEC 11581: Icon symbols and functions
ISO/IEC 14754: Pen-based interfaces - Common Gestures for text editing with pen-based systems
ISO/IEC 18021: Information Technology - User interface for mobile tools
ISO DTS 16071: Guidance on accessibility for human-computer interfaces

Games Technology

Executive Summary

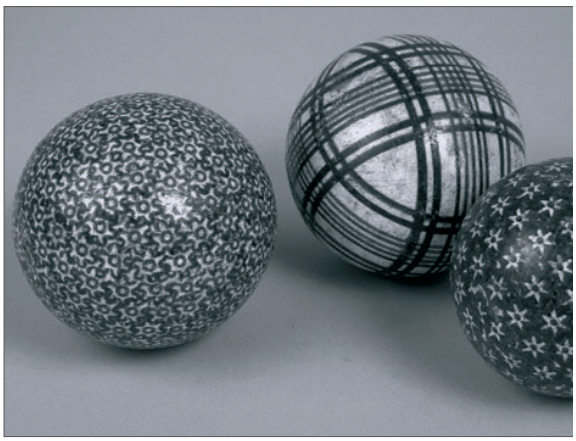
Gaming is a natural human instinct and evidence of human involvement with games stretches back across the past five millennia. Games have made the transition from board to desktop with fluidity, and the information age, with its new platforms and devices, provides an ideal medium for the improvement of games technology. In the United States of America, sales of computer games already exceeds those of books, while in the United Kingdom games sales outstrip video rentals by 80%.[101] Clearly, this is an increasingly powerful industry.

The spread of games is potentially limitless. They can be run on desktop or handheld computers, dedicated static or portable gaming consoles as well as mobile phones and interactive TV. Basically, where there is a processor and a screen the potential for games exist.

Games can be divided according to their genre, the online or offline playing modes and the involvement of one or more players.[102] In the last years massive multiplayer online games have become more and more popular. Most essential for the development of games in recent years has been the development of computer graphics, virtual environments and multi-agent systems. More popularity gains have been made by the so-called *edutainment* applications, which combine educational content with entertaining forms of presentation.

One recent trend has been to produce games with a historical setting and 'feel', offering obvious potential for heritage organisation involvement. Such games could increase the knowledge of players of historical settings and could provoke interest in visiting collections. Games are a specific product with an enormously wide potential audience. They remain under-used by cultural heritage institutions at a time when their potential could be being harnessed in order to expand awareness and knowledge of collections through 'edutainment' packages and other strategies.

Following a brief history of the first 30 years of electronic games, this report explores the potential uses of modern gaming technology in the cultural heritage sector and features an examination of those technologies which may be most applicable in future heritage work. Featured case studies include the French **Réunion des Musées Nationaux** and Berlin's **Digital Game Archive**.



101 http://www.digiplay.org.uk/facts.php
102 Although highly popular and lucrative, this report will not cover Internet gambling, another form of online 'gaming'.

An Introduction to Games Technology

Basic principles

Games have been a part of everyday life for several thousand years. Archaeologists have uncovered a complete set of gaming equipment which dates from 3000 BC and another game – Wej-qi, a precursor to the game Go – was discovered in China and dates from around 2000 BC. The play instinct, it seems, is a fundamental aspect of humanity.

Gaming and communications have been the two human fundamentals that have made the leap into the information age with the greatest fluidity. Broadly speaking, the term 'gaming' covers a variety of applications on a variety of platforms, including dedicated consoles, personal computers, mobile phones, handheld/self-contained game units and public game machines. This report will concentrate on console and computer games as these provide the most possibilities for presenting content related to the cultural heritage sector, though potential future uses on other platforms will be highlighted. At present, games on mobile phones and portable units are very limited in content and possibility, though online gaming is a rapidly expanding area.

Most games involve simulation of one kind or another and tend to be divided into different categories or genres depending on their level of realism. Flight and driving simulators are very popular, as are team sport and 'god' games. Role-playing and adventure games tend to be more abstract and increasingly cerebral in nature. Simple adaptations of traditional games and puzzles remain very popular as well, particularly when bundled with an operating system or a particular mobile phone.

The **Digiplay Initiative** (http://digiplay.org.uk/) found that 73% of seven to 29-year-olds has played computer games at some time, with 25.8% playing every day and 47.6% on most days. In the USA, sales figures for games have overtaken those of books and in the UK the gaming market is worth 80% more than the video rental market. These figures speak for themselves and the usefulness of gaming technology in stimulating interest in (and increasing accessibility to) cultural heritage resources is a focus of this report.

Where is games technology used?

Though primarily found in the home as an entertainment device, games are not restricted to this environment alone. The business sector has long used games and simulations to train people in developing fiscal, economic and trading skills, and the military uses simulation-based games in combat training. The health sector is increasingly using techniques and technologies similar to those used in games to simulate the effects of drugs and illnesses on the human body and in veterinary medicine to teach students potentially hazardous techniques. Aircraft pilots and racing car drivers frequently use simulations in the early stages of training in order to familiarise themselves with the often very expensive equipment without the risk of physical or fiscal damage.

How the Technology Works

A brief history of video game systems

The first commercial arcade video game, *Computer Space* by **Nutting Associates**, was introduced in 1971 and the next year **Atari** released *Pong*, the first commercially successful arcade video game. In 1975, Atari launched a home version of *Pong* which was a great success and opened up new horizons for home entertainment. Although the **Fairchild** *Channel F*, released in 1976, was the first true interchangeable game system, **Atari** once again had the first commercial success. Introduced in 1977 as the **Atari** *Video Computer System* (VCS), the model 2600 used removable cartridges, which allowed a multitude of games to be played using the same hardware. Systems like the *Atari 2600*, its successor the 5200, **Coleco's** *ColecoVision* and **Mattel's** *IntelliVision* helped to generate interest in home video games for a brief period. But interest began to wane as the quality of the home product lagged far behind the technologically-advanced standard of coin-operated arcade machines.

In 1985, **Nintendo** introduced the *Nintendo Entertainment System* (NES). This development transformed the gaming industry. The NES established three concepts that were widely adopted in the video game system industry:

- The use of a pad controller instead of a joystick;
- Authentic reproductions of arcade video games for home use; and
- An aggressive pricing strategy that meant making a loss on the hardware but recouping this against the number of games sold.

Nintendo's strategy paid off, and the NES sparked a revival in the home video game market that continues to thrive and expand today. Home video game systems were no longer mere imitations of arcade machines and new game ideas that would have been impractical to create even for commercial systems were developed for the home market. While **Nintendo** continued to develop and introduce new game consoles (*Super Nintendo*, *N64*, *GameCube*), other companies such as **Sega** (*Megadrive*, *Dreamcast*), **Sony** (*PlayStation*, *PlayStation 2*) and **Microsoft** (*Xbox*) developed and released their own home systems.

Current systems often boast additional functionality, such as modems, compact disc players and DVD drives. These features can be used to enhance the gaming experience, and they can be used independently for email, Web browsing, and listening to music. This broader functionality has cemented the gaming console's position in the home and, to some people, the *PlayStation 2* has become as essential an item as the television or telephone.

System basics

What is a video game?

The terms 'video game' and 'computer game' are generally used interchangeably, regardless of whether a computer or a console is involved. Typically there will be a screen (TV, monitor, liquid crystal display (LCD)) through which the game is viewed. Input devices vary depending on the particulars of the game and hardware, but usually include a controller, joystick, keyboard/keypad, or mouse.

Games can be played on a variety of platforms, ranging from dedicated gaming consoles used in conjunction with a normal television set to standard home computers or standalone handheld consoles and electronic devices such as mobile phones and handheld PC's, instruments that were not originally designed for gaming but on which gaming has become popular.

There are no hard and fast rules about what is and what is not a game and 'games' may range from hi-tech Global Position System (GPS) populated golf simulators (**Microsoft's** *Links 2003*) to blocky and primitive 'timekillers' such as **Nokia's** proprietary *Snake* series for mobile phones.

Basic hardware

The hardware used to play games has remained remarkably similar since the birth of removable cartridge game systems. Most video game systems will have the following components in common:

- User control interface. The user control interface allows the player to interact with the video game. Modern consoles use sophisticated controllers with a variety of buttons and special features. Computers use standard input devices such as keyboard, mouse and joystick, while games on devices such as phones and handheld PC's most often use existing buttons and alpha-numeric keypads;
- A Central Processing Unit (CPU) carrying out the fundamental computing tasks;
- Random Access Memory (RAM) which provides very fast temporary storage space for games to make use of. Without RAM, games would not be fast enough to maintain the goal of interactivity;
- Software kernel or that part of the operating system which provides interfacing duties between the various pieces of hardware;
- Storage medium for games. The most common storage technologies used for video games today are CD, DVD and ROM-based although cartridges, memory cards and hard disks are used by some makes of console;
- Graphics processors used to provide mapping, texturing and geometric functions as well as controlling the video output to a television set or an inbuilt screen;
- Audio cards to handle and enhance sound.

Types of games

The game software has evolved amazingly from the simple rectangular blips used in *Pong*. Games today feature richly textured, full-colour graphics, powerful sound and complex interaction between player(s) and system. The increased storage capacity of computers and consoles allows game developers to include incredibly detailed, almost photorealistic graphics as well as CD-quality soundtracks. Many video games have built-in software[103] that adds unique features like lighting effects or real-time texture mapping. Just as there are said to be only seven essential stories that can be told[104], most games fall into one of several broad genres (examples given in brackets):

103 When game systems were cartridge-based, the cartridges would often contain proprietary hardware as well.
104 Cinderella, Achilles, Faust, Tristan and Isolde, Circe, Romeo and Juliet, Orpheus.

- **3D Action/Adventure** (*Tomb Raider, Portal Runner, Army Men*) May feature space travel, virtual team sports, treasure quest and all sorts of settings where the aim is to pass through obstacles and solve puzzles;
- **Strategy games** (*Zelda, Final Fantasy series, Heroes of Might and Magic*) In strategy games, players control some assets, such as natural resources and military units, against opponents (real or computer-controlled) who are trying to gain more wealth, power and/or territory;
- **Simulation** (*IL-2 Sturmovik, Links 2003, Maestro Music*) Games based on realistic, real-time action simulation of some real-life experience such as flying a jet and playing golf.
- **'God' Games** (*Civilization, The Sims*) Players create, manage and influence characters, families, villages etc. These games are likely to include some features of strategy, simulations and role-playing;
- **Fighting** (*Mortal Kombat, Soul Blade*) No explanation required;
- **Puzzle** (*Tetris, Worms*) Generally simple games which get increasingly difficult as the player progresses. These tend to be highly addictive;
- **Shooter** (*Doom, Quake, Unreal Tournament*). Popular type of action games wherein the player takes on some bad guys (or the world), usually in gunplay scenarios used to represent spy missions, alien invasions, and robberies. Shooter-type games may be presented from a first- or third-person perspective;
- **Platform** (*Jet Set Willy, Super Mario Brothers*) Players manipulate a character over many levels and around many obstacles and puzzles;
- **Racing** (*WipeOut, Tokyo Xtreme Racer*)
- **Conversion** (*Who Wants to Be a Millionaire?*) Cash-in products from popular TV shows;
- **Role-Playing Games (RPG)** These are typically used in fantasy and science fiction genres. They allow players to create and develop characters in a simulated environment;
- **'Edutainment'** (*Versailles II, Egypt, Forbidden City*) See Case Study III, below.

Of course, many games include elements of two or more of these categories and others defy categorisation altogether. Developers tend to prefer investing in genre-type games, although they recognise that the biggest-selling titles are often those that have unique characteristics in concept or execution. *Parappa The Rapper* is a good example.

At first glance, first-person shooters – with their connotations of carnage and destruction – may seem an unusual topic for a Cultural Heritage audience. This is not necessarily so. **THEATRON** (see above) has considered the use of *Quake* environments in future developments to improve realism in the exploration of and interaction with reconstructions of historical theatres. These improved environments would act as a supplement or replacement to the standard VRML browsers currently used by the project, with more intuitive controls leading to a more immersive and illusory experience overall.

Online and offline gaming

Another way to classify newer games is according to the potential numbers of (simultaneous) players and whether or not they use networking technologies. Multiplayer games, both online and offline, may be played at home, at school, in the office or virtual 'cafes'. These could be single-player games that are hosted online (many of them as freeware or shareware), team-play games (from two to 30 players), as well as Massive Multiplayer Online Games (MMOG's) with thousands of simultaneous players. MMOG's make use of vast virtual territories supported by server networks, allowing players to interact simultaneously and seemingly seamlessly over the Internet. The most prevalent among these are fantasy and science-fiction role-playing games, battle strategies and 'god' games. Consoles are beginning to make their first moves into online gaming, with *Phantasy Star Online* for **Sega** *Dreamcast* the first title to allow this. *Xbox* is another product with a subscription service for online gaming.

Other net-based gaming environments are possible. Simple and attractive games may be written using **Macromedia's** *Flash* which offers a low-cost alternative to the types of games outlined previously. A *Flash* licence costs around €60 under **Macromedia's** Education Licence Programme. *Flash* syntax lies somewhere between *Java* and *JavaScript* and, as most IT and computing science departments have a basic grounding in one or both of these languages finding or training suitable personnel need not be overly difficult or expensive. A *Flash* game requires a smaller programming team and useful games can be written by one programmer rather than the large teams that are needed for today's blockbuster games. The *ARKive Project* (@Britstol, http://www.arkive.org.uk), which is building a data resource of audio, still and moving images, and text about endangered species in the British Isles, has made very effective use of games constructed in *Flash* as part of its education outreach activities.

Numerous games which demonstrate the potential of *Flash* in the education and heritage sectors are freely available online. A large game repository, such as **http://www.flasharcade.com**, gives a quick overview of the range of different applications for *Flash*. Puzzle games based on popular templates matching colours, shapes and other patterns can encourage learning and exploration. *Flash* has the facility to create applications which incorporate video and formats supported include MPEG, Digital Video, QuickTime and AVI. Rich media objects can be animated and resized and scripts can be written to increase their interactivity. *Flash* content can be supplied to any browser, platform or device that supports the technology, including PC's, personal digital assistant (PDA's), gaming consoles, interactive TV's and 3G mobile phones. **Macromedia** works with leading providers to ensure broad compatibility across desktop, home and mobile device platforms.

Flash content is not as technically advanced as some other forms of gaming technology, but its strength is its widespread compatibility, its ease of use and its low cost development environment.

Equipment issues

Console-based systems

A video console is essentially a highly specialised, single-purpose computer and over 100 million consoles are in use globally with numbers increasing by the day. Most sys-

tems are based on a central processing unit similar to those used in standard desktop computers. To keep the cost of the video game system within reasonable limits, most manufacturers use a CPU that has been available on the market for long enough to have undergone a significant decrease in cost.

Consoles tend to be cheaper than PC's, with prices ranging from a high end of about €200 for the Sony *PlayStation 2*, to less than €40 for an older, second-hand system. Consoles have other advantages including quick loading times, automatic booting procedures and robust (but focused) operating systems. From the perspective of the user the degree of technical knowledge required to set up and use consoles is much lower. Most game consoles are truly 'plug and play' and video game systems are designed to be one part of a larger home entertainment system. This means that they are easy to connect to various audio-visual devices, allowing larger screens than PC's' to be used for their display.

There are no difficulties with compatibility issues often created by operating systems, *DirectX* drivers, audio and graphics cards, and incompatible game controllers. Each type of console has a fixed specification and the graphics, internal memory, and drivers are identical across all units of a particular model. Components of desktop PC's from memory, to graphics, to peripheral devices (e.g. sound cards) evolve regularly, hence games developed for contemporary PC's may be incompatible with older machines due to a lack of memory, an unsuitable graphics card or driver or some other hardware or software shortcoming.

While PC operating systems and software are prone to 'crashes' or 'lock ups' this very rarely occurs with games consoles as game software is designed and tested rigorously against known and fixed hardware and software specifications.

PC-based systems

With the advanced power of today's graphics boards and processors, huge amounts of RAM and GHz speed CPU's, the raw power of the desktop PC can certainly keep up with the pace set by leading-edge consoles. PC's have hard drives which allow large amounts of information to be stored and accessed in the background. Most games consoles lack this, although **Microsoft's** *Xbox* is a notable exception, and tend to rely on removable memory cards. As a result, they often struggle to load appropriate code in advance of when it is needed; this failure makes the games appear hesitant. PC's allow gamers to increase the capabilities of their gaming platform and increase their enjoyment of the game with expansions and upgrade packages.

With modem and online connectivity, players can challenge each other in multiplayer environments online and achieve more personal prestige and recognition for their accomplishments. Console makers are catching on to this and new units tend to have modem connectivity and multiplayer functionality as standard. As well as performing general tasks, the PC along with the Internet opens the door to a million creative spin-offs. Inbuilt game-editors encourage gamers to build their own levels, game fans fill nicely designed Websites with hints and tips, and friendships and game 'clans' are formed over the net.

Game development for consoles requires expensive software and hardware leading to a 'closed shop' environment. However, PC developer communities tend to be more open and inclusive, as it is relatively easy to develop software or applications directly onto and for the PC using a wide variety of tools and programming languages.

In the future, it is expected that PC's will continue to be used for general day-to-day tasks like Web browsing, email, word processing and games that require higher technical

specifications, such as first-person shooters and simulations. Meanwhile, consoles will focus increasingly on action-centred games such as fighting and sports simulators with added functionalities as a bonus or convenience.

Other systems

Games tend to work their way into all kinds of environments where they may not have been foreseen. Portable versions of desktop PC's, PDA's and handheld computers may have been developed for serious use, but games such as chess and poker are popular with handheld users for whiling away long waits in, for instance, airport departure lounges. These games tend to be less sophisticated than PC games but their focus is more on amusement than the elusive 'wow' factor.

Mobile phones often feature built-in games, such as *Snake, Space Impact* and *Pinball*. Games can be downloaded from the Web and this can generate significant income for their creators via high download charges and add-on functionality such as extra levels or opponents.

Handheld consoles, such as **Atari's** *Lynx* and **Nintendo's** *GameBoy*, tend to be popular with younger children. They are more or less the same as larger consoles except for their inbuilt displays and their capacity for battery operation for use on the move.

Game development

Stages of games development

Computer science is not the only academic subject of relevance to video game development. Indeed, as middleware, software tools that assist with game creation, becomes more widespread, so the necessity to program in formal programming languages will become less important. A brief examination of some broad gaming genres will reveal features of relevance to other academic areas. For example, in-game landscape building and community recreation may be associated with geography and urban planning, engineering and physics are essential to the realistic simulation of vehicles, history is useful for accurate re-creations of events, characters and societies and the arts have much to offer in character development, as well as music for sound effects.

The process of video game development can be divided into several stages:

A. Defining the game idea

Each game starts with an idea that can originate from a variety of sources. Sometimes it is an original concept, at others it is a sequel to an existing successful game, and at others it might be a spin-off from a movie character or storyline. In other instances it can be a simulation of another real world game, event, or scenario.

B. Preparatory stage

This stage encompasses the following activities:

1) Assembling the development team. Depending on the complexity of the game under development, the team may involve directors, designers, software engineers/programmers, artists, and story writers.

2) Development of the story line. This identifies the theme of the game, the main characters and the overall plot, as well as the type of gameplay interfacing

required and precise details about how the game will use the technology available on a particular platform. Games are often developed on a number of platforms simultaneously, requiring separate teams and a co-ordinator to ensure a unified approach.
3) Storyboarding. Storyboards are collections of drawings and technical instructions that describe each scene of the game. These may include full motion sequences that introduce the story, or continue it between the periods of actual gameplay. This is one way in which the games industry is becoming increasingly competitive with Hollywood.

C. Development stage
This stage involves the development of 3D models and texture maps that will make up the worlds of the game and the animated full motion video sequences. The game code will be developed at this stage, potentially including a 3D engine for generating polygons, shadows and textures in the game scenes, as well as the code for Artificial Intelligence that the interaction of objects and the movement of the characters. A 'tool chain' will combine the different codes in an executable sequence.

D. Final preparation
Refining the game, including optimisation of the game code for the fastest possible running speed, potentially reducing the polygon count, optimising the game logic, adjusting the clipping planes which restrict the image content depending on how 'far away' the user is from an object and culling, leaving non-visible objects or elements unrendered until the user is almost 'within sight' of them.

E. Post-development stage.
This stage will generally involve product testing, acquisition of Entertainment Software Rating Board (ESRB) rating, marketing, advertising and distribution. The development of video games is an expensive business. A multitude of costs have to be covered such as console licensing royalties, advertising, salaries for the production team (a typical game may employ forty people for a year or more), other licensing fees, operational costs and so on. In costing and pricing games, companies take into account the short lifespan that most games enjoy.[105]

Personnel and roles

A variety of different roles and personnel will be necessary to create a hit game. 2D Artists make textures for landscapes and skin-textures for characters, and usually work with *Photoshop, Paint Shop Pro*, and *The Gimp*. 3D artists make models for games using software such as *3D Studio Max* and *SoftImage*. Animators bring the drawings to life in 3D and 2D games, initially making a model in *3D Studio Max* or *SoftImage* and later applying animation techniques to it. Level designers create the game world and its architecture inside a 2D/3D level editor. Many game engines come with their own inbuilt editor. Programmers are fundamental to the team and may use a variety of proprietary and other languages,

105 These are the standard steps for creating a big-budget title. It is not suggested that culture heritage organisations would have the time or resources to develop games to this scale, but it may be useful to learn lessons from the 'masters'.

often C++ and specialised code editors. Sound Designers add music and sound effects using programs like *Sound Forge* and other sound library collections and software. Writers create captions and storyboards as well as the technical writing necessary for game manuals, guides, character dialogue and other in-game documentation. The whole team should be organised and co-ordinated by game producers and project managers.

When developing specialised games such as flight simulators consultants provide guidance on domain-specific topics. Cultural heritage organisations would be likely to use specialists in particular subject areas to confirm the authenticity of the storyline and how it is presented.

Dedicated development environments

To facilitate the game development process, many companies offer specialised game-development environments designed to assist users without programming experience. Usually, such products offer a variety of game scenarios with hundreds of pre-made and adaptable scenes together with collections of 3D objects and sounds. These allow users to personalise their games by adding sound effects and images, importing 3D models from other sources and saving games as executable files.

Game Maker[106] is a freeware program written in Delphi which allows users to create computer games without writing code. It is based on drag-and-drop and WYSIWYG (What You See Is What You Get) techniques. *Game Maker* can be used to create games of different genres with appropriate backgrounds, animated graphics, music and sound effects.[107]

Applications of games technology

The global computer and video game industry generates revenues of over €18.5 billion per year and forms a major part of the entertainment industry, often matching and occasionally exceeding cinema revenues. This huge sum may create the feeling that heritage organisations could have little use for games, given their budgetary differences. This is not necessarily the case. Efforts could be made to find new ways of exploiting gaming technology in the cultural heritage sector. Given the dramatic effect that the games explosion has had on moviemakers and booksellers, the power of this new medium should be harnessed to complement and facilitate the delivery of cultural content. There are numerous games which purport to present some kind of historical or mythological setting. However, the games which actually achieve this authoritatively are a tiny minority. This is a field wide open for heritage work.

The primary application of games seems obvious. They are designed for entertainment. Recently, however, the gaming industry has begun to venture into new territories.

The integration of computer games with other media or platforms, such as PC, television, mobile phones, digital radio, console and handheld devices has been a trend, although the few successful examples in the latter field (*Pokemon, Who Wants To Be A Millionaire?*), still cannot really be described as having true integration and seamless connection with different media types.

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106 http://www.cs.uu.nl/people/markov/gmaker/index.html
107 A number of comparable commercial products exist. A good list is maintained at http://www.ambrosine.com/resource.html

The development of online gaming is another attempt to integrate different means of interaction outwith a game. This in particular may be of great relevance to the library and information community. *World War II Online*, for example, has Websites in which game strategies, weapons and real-world history are discussed. In another game, *Majestic*, the boundaries between game and everyday life are blurred, as players can receive phone calls, faxes and emails as part of everyday life. *Everquest* allows complex and simultaneous in-game interaction between thousands of people, irrespective of their physical location. In these games, people can exchange information, 'fight', move through virtual worlds, and observe the actions of other gamers. Unfortunately, to date and to its loss, the informatics sector has not yet carried out a detailed investigation in to online gaming to see which techniques, technologies and concepts may be transferable to systems using information access, discovery and management.

Games Technology and the Heritage Sector

Brief background

Games are designed to sell and, therefore, they have to be attractive, fun, challenging and rouse our curiosity. Because of their growing ubiquity and increasingly attractive graphics and packaging, people from many fields are looking at the potential of games for exploiting delivery of their messages. The importance of games is illustrated by the emergence of a number of game-oriented research institutions, amongst them Scotland's Abertay Dundee and Liverpool's John Moores universities.[108]

Until quite recently, academic research and social response has focused not on the programming of video games, but rather on the continuous societal concern related to violence and sex present in games and to behavioural habits which games may instil in children. But now, increasingly, other academic faculties are getting involving with the gaming sector including the arts (graphics and character design), music (soundtracks and special effects), architecture (building design and layout), engineering (vehicle dynamics and handling), history (providing accurate detail from real events and processes), geography (presenting landscapes and settings), literature (collaborative script construction), biology (accurate plant and animal growth and behaviour) and sports (how characters move).

One of the most exciting areas where research and cultural heritage institutions may overlap in the gaming sector is that of education and learning. This can involve using games to enhance learning and using the technologies and techniques to design and produce more effective learning software and material. Of course, this raises questions about how games technology can be best presented in the museum environment. To ensure that games are as unobtrusive as possible and blend in with the other displays and objects will require a significant degree of forethought.

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108 IC CAVE research centre, University of Abertay Dundee, Scotland: http://www.iccave.com;
International Centre for Digital Content, Liverpool John Moores University and Mersey Television, England: http://www.icdc.org.uk;
Digiplay Initiative, Centre for Research on Innovation & Competition at Manchester University and Department of Psychology at University of Central Lancashire, England: http://www.digiplay.org.uk/index2.php

Case studies

Case Study I –The Computer Game Museum and the Digital Game Archive, Berlin[109]

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The Digital Game Archive at the Games Convention, Leipzig, August 2002

The Computer Game Museum, founded in 1996 by a group of enthusiasts who shared a strong conviction that computer and video games are much more than mere toys, opened to the public in 1997. It was the world's first permanent exhibition dedicated solely to interactive digital entertainment culture. The museum aims to offer consumer education for users of computer and video games, to foster a playful and creative approach to technology in order to counterbalance its 'dryness', and to help potential users overcome this fear and anxiety of the newest technologies. As the organisation has evolved it has focused on encouraging the acceptance of gaming, and increasing awareness of how games and gaming have become a facet of our culture.

The Museum has a collection of around 15,000 titles, complete with their original boxes and manuals. The collections include almost all home computer and gaming systems. Additional material such as specialist magazines and ephemera are acquired to provide contextual material for researchers. The collection of original games is stored on shelves in dedicated storage rooms, and relevant metadata is input into a database.

The **Digital Games Archive** (DiGA), established in Berlin in 2002 as a partner organisation to the museum, is creating a unique digital game archive on the Internet. It encourages the free download of commercial computer and video games, which have been voluntarily deposited by the licence holders. The goal has been to preserve an exciting segment of our digital cultural heritage, and to make this material accessible for future generations.[110] At the moment the museum has freeware emulators for almost every hardware platform, but this availability does not completely ensure the future survival of the games. It may be necessary to develop new kinds of emulators, with a preference for those developed in an open-source environment.

© The Digital Game Archive

The Digital Game Archive at the Games Convention, Leipzig, August 2002

The archive has run into a certain amount of difficulty with commercial game publishers. Traditionally the publishers have more reservations about archiving and free downloads than have the game developers themselves. On occasion they have taken legal action against so-called 'abandonware' sites offering free

109 This case study is based on a questionnaire completed by Andreas Lange, founder and CEO of the Digital Game Archive (http://www.digitalgamearchive.org), and director of the Berlin Computer Game Museum (http://www.computerspielemuseum.de). The websites of both organisations were also consulted, and the questionnaire was completed in early February 2003.

110 See http://www.digitalgamearchive.org/diga.php for more on DiGA's goals.

downloads of games which are no longer commercially available. If the developer is also the licence holder (which is no longer common) they are more likely to allow the free copying of the program. Many early computer games were written by single programmers, working from home. Authors of early computer games tend to be much more liberal in allowing free downloads for non-commercial purposes, and developers tend to be more interested in their games still being played than in making further profit from them. In these cases the authors retain the Intellectual Property Rights, and can continue to exploit their work commercially as well. The variance in copyright law in different countries is likely to be one of the archive's more difficult obstacles.

In any case, the archive only offers games with the express permission of the licence holder. There are not many games available at the moment[111], but the archive staff anticipates that the gaming industry will come to recognise its responsibility to the cultural memory of society, and the place of games in our social fabric. So far, the gaming industry has shown little interest in archiving the digital gaming tradition. The main reason for this is the dynamic nature of the gaming marketplace. Companies have no staff available to carry out non-profit-making tasks. Many companies have short lifespans, and as a result much information has been lost in this way.

Library, archive and registration systems, which are usual for other media, have not yet emerged in the game sector, and it is not easy to find the code or even the licence holder for a game which is older than five years, with the exception of blockbusters such as *Tetris* or *Pac-man*.

© The Digital Game Archive

The Digital Game Archive at the Games Convention, Leipzig, August 2002

The game programs themselves are currently stored on a server; the archive staff realise that this is not an ideal solution. One of the main reasons why DiGA was founded was to develop a best practice solution for the storage and maintenance of legacy gaming software. To help it develop its expertise and infrastructure it hopes to attract project-based funding for research in the cultural area. At the moment DiGA is funded by private investment and propelled by the idealism and know-how of its members, but it is working to establish a regular stream of funding.

Case Study II – Virtual Nagoya Castle[112]

Virtual Nagoya Castle is a shared virtual environment which has been developed as part of the **Orbis** project. The castle becomes a meeting point for English and Japanese speakers whose aims are to learn each other's language. Users take on 3D humanoid forms and their avatars walk around the virtual landscape, receiving language lessons and testing their progress with other visitors.

Before 'entering' the castle, the first step is to download a collection of VRML files from the *Project Orbis* Website. These files are held on the user's own computer in order to achieve optimal performance from the virtual world. In addition to the Nagoya Castle

111 There are currently five games available (14/02/2003)

112 This case study is based upon material from the Webpages of the ORBIS project, (http://www.okada.ecip.nagoya-u.ac.jp/~chris/ORBIS, and http://context.mit.edu/imediat98/paper), visited on 22/01/2003.

files, users can download other necessary material including Japanese font support software. While VRML is the primary technology used in the general exploration of the castle, Java is used to allow the model to handle events and behaviours that are beyond the capabilities of VRML.

The castle can be explored in a number of different modes: navigating, communicating, translating and learning. Since the VRML files are held locally, navigating and learning modes do not require the user to be connected to the Internet. When connected the user can receive updated files, interact with other users using voice and text chat and have access to a dynamic bi-directional dictionary for translations. A virtual teacher is on-hand to assist the learners.

Developers of the *Virtual Nagoya Castle* claim that the multi-user environment boosts foreign language acquisition. The entertaining setting makes this experience similar to a game, with the presence of the user in the form of an avatar walking around and chatting with other learners and native speakers of the study language. The developers hope to begin work on speech recognition capabilities in the near future. If the virtual teacher can be made to recognise what a student is saying, it can guide speaking practice, improving the interface and usability of the environment. Work is ongoing to allow personalised avatars for each user which will be more engaging than the default avatars that are currently in use.

The *Project Orbis* team is concerned with further exploration of how varied language exposure can help students. This situation is comparable with a real-world language class where students learn from each other as well as from their teacher. The work on avatars brings the touch of games development to the subject matter, and the interdisciplinary combination of an enjoyable and culture-heavy virtual setting with foreign language students has been a success.

Case Study III – Réunion des Musées Nationaux[113]

The Réunion des Musées Nationaux (RMN, *Assembly of National Museums*) is a network of 33 national museums in France. It has long had a highly competent art publishing department and has developed a strong interest in new communication technologies and multimedia. In 1993, the RMN set up a multimedia department and began to produce and publish interactive products. Their catalogue of cultural CD-ROM's now numbers some fifty titles covering five major areas:

- Museums, exhibitions and art history. The role of the RMN's multimedia department is seen not only as an enhancement to the permanent collections in the museums' network, but in promoting temporary exhibitions;
- Games. In 1996, the RMN invented a new genre with its cultural heritage game, *Versailles 1685, a Game of Intrigue*[114], in which the player discovers world cultural heritage from a specific period;
- Encyclopaedias;
- Programs to make art accessible to young people;
- Printing workshops that allow users to print their own materials such as bookmarks, postcards, posters and calendars featuring famous masterpieces.

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113 This case study is based on material from the Webpages of Réunion des Musées Nationaux (http://www.rmn.fr/index-gb.html) and Cryo (http://www.cryo.fr), both sites visited on 22/01/2003.

114 Versailles 1685, a Game of Intrigue: http://www.museesdefrance.com/en/fiche.asp?code_reg=AV500064&partenaire=rmnfr

For its games developments, the RMN has forged a successful partnership with a company which specialises in this area, **Cryo**.[115] Following *Versailles*, **Cryo Interactive Entertainment** in conjunction with RMN and the Palace of Versailles developed the second part of this historical adventure, entitled *Versailles II, The Testimony of the King*.

This game takes the player to the Palace of Versailles and the court of King Louis XIV during the most important event of his reign: the inheritance of the throne of Spain. The game story presents the two possible successors, the French King Louis XIV and the German Emperor Leopold I, try everything from diplomatic missions to espionage to accede to the spanish crown.

England and Holland are attempting secretly to make separate arrangements with the French King. On this vast historical scenery, the young, penniless Charles-Louis de Faverolles arrives in Paris in 1699. His only treasure is a recommendation letter but his ambitions are for a diplomatic career at the Court of Spain where he spent his childhood and fell in love with the noble Elvira. In order to succeed, the young man has to overcome many plots and obstacles.

An essential characteristic of the game is the historical validation of its content. As one of the authors of the game, Béatrix Saule, conservator at the Palace of Versailles says, 'The aim of the game is to make the player revive the history. The problem was to conciliate the game with the real historical facts. In order to solve it, it was necessary to follow the events describing them with details and trying to find out episodes where incertitude could be introduced with a high level of authenticity.' In fact, this is the key to producing a game of this sort: exploiting uncertainty for situations where the player must make decisions comparable to those in the real historical scenario.

The documentary base of the game is presented in the form of a journal, containing a vast collection of reference material from the court to refresh the player's knowledge, or to allow him to learn about this period of history. At the same time, items found in the journal will be helpful for making correct decisions during the game. Documents are grouped under five main topics: A Town Within a Town; Princes and Subjects; The Court Within Its Garden; Public and Private Histories; and Life at Court. The developers enhanced the sense of authenticity by incorporating among other audio features baroque music from the period. Help facilities are built into the product.

The game was developed by an eclectic team including some 20 specialists such as conservators, historians, special effects and game designers, programmers, musicians and garden and fountain experts.

The game is offered on CD-ROM and DVD for the PC and Mac environments. Two other collaborations between Cryo and RMN, *Egypt* and *Forbidden City*, have already been adapted for DVD. Programs have been developed to use the DVD-ROM's potential for storing images, video, sound and animation which was applied in the RMN products *Louvre: a virtual visit and The 20th Century*, the latter produced jointly with **Encyclopaedia Universalis**.

Cryo offers other games oriented to historical periods presenting the history of (among other places) Egypt, Jerusalem, Pompeii, and China. What makes a noticeable difference with this particular experience is the careful study of historical setting and the incorporation of real historical facts into a game.

115 http://www.cryo.fr

Scenarios

Scenario I – Discussing a game idea

A local museum is planning to present part of its collection in the form of a game instead of a standard printed, online or CD catalogue. The management would like to cover the investments for the game development with the sources from its sale. It runs an internal competition amongst museum staff to come up with ideas for the content of the game. The management aims to improve the sales of souvenirs from the museum shop and increase visitor figures. Another fundamental aim is to give children more approachable access to knowledge about the collection. The management team consider a number of issues as they decide what steps to take:

- What is the development risk? The management has figures for sales of catalogues that were produced basically for the adult visitors but which do not take children into account. It is unclear how many parents would buy the game.
- What game genre to choose? It has been agreed that the game will be for one player, delivered offline, but the genre best suited to presenting the material while retaining user interest and excitement has yet to be decided.
- What partner company, experienced in game development, would cover the quality and content criteria?
- What will be the time framework for the production?
- The collection is already digitised, but who will determine whether any of the objects will need to be re-digitised for the purpose?
- Since the accent is on education, the management has decided to incorporate virtual reconstructions of items. Who will provide these and how?
- One of the ideas is to allow players to incorporate their own picture selections of museum items and gallery drawings not bound by copyright. How could this idea be incorporated into the game?
- Who will develop a set of quizzes and puzzles?
- Will the graphics and user interfaces be state of the art when the game is released?

In-depth discussion of these matters should clarify the strategy and help the management to prepare, release and evaluate the finished game.

Scenario II – Making a VR game from the ruins of an old castle

A team from a local university aims to build a 3D reconstruction of an old castle in their area. This work will thus provide a tool for historians to visualise alternative architectural features requiring a high degree of flexibility within the computer model,

© Boyana Church Project

The Boyana Church: real and virtual representations

allowing users to view different versions of the castle and to move walls. The model will be used for educational purposes, presenting the traditional architecture from the period to students who would then be able to play with and modify the presentation. The team, which includes historians, archaeologists and a computer scientist, decided to use VRML for building the model, to facilitate its eventual placement on the Web.

The castle was built in the 16th century and demolished 300 years later. Excavations performed in recent decades have led to a clear floor plan being drawn up. Detailed studies are made of the fragments of building materials which could be compared with other buildings from the same period which remain standing. Other sources of information are utilised, including several dozen drawings and textual descriptions of the castle from across its lifespan. These lead to different accounts of the actual shape and physical make-up of the castle, all of which will have to be incorporated into the model. A set of questions, for example what was the initial shape, what rebuilding was done, had the castle been partially destroyed and then rebuilt, can thus be plausibly modelled and answered.

Since the interior of the castle did not survive, this was not included in the model, although there is much historical evidence regarding the typical interior objects and designs. This could be implemented at a future stage of the project, if time and resources allow. The virtual reality reconstruction allows the user maximum freedom to move debateable elements, such as walls, towers and gates. The result allows specialists to check their theories against visual representations. The work is made available to teachers in history who can lead their students around the virtual and real sites, providing an excellent way to add context to their study of local history.

Benefits and Risks

Summary

The most widely discussed benefits and risks of games relate to the health and overall well-being of regular and/or excessive users. The following are among the potential benefits of games for personal development:

- Certain genres like 'god' games and simulation games can help to develop thinking and problem-solving skills, while action games are widely promoted as improving reflexes and co-ordination;
- Role Playing Games help develop critical thinking and reasoning ability. Games based on historical content may develop historical interest, together with accompanying literary and cultural references. These references are not always accurate in commercial products; cultural heritage institutions can provide valuable support in redressing this shortcoming. To cope with all sorts of floor plans, maps, mazes, puzzles and placement of objects within 3D environments the memory skills of users are often enhanced. Spatial reasoning is necessary in order to succeed in many such games;
- Some games incorporate foreign languages or are played by young people who are not native speakers of the language of the game. Games can contribute to developing vocabulary and literacy. They can be used to offer users vivid real-world geographical

and cultural representations and experiences;
- Although they may be time-consuming, games can be a good topic for joint discussions with family and friends;
- Team games promote the development of collaborative skills.

This variety of potential benefits represents one side of the coin. On the other side are the risks of addiction and psychological abnormality. Some games, particularly blood-thirsty first-person 'shooters', develop super-quick reactions accompanied with an artificial increase in heart rates and adrenaline levels, which may pose a health risk.

Tabular overview

Benefits	Risks
Developing specific skills (motor skills, reasoning, spatial orientation).	Potential exposure to violence and sex patterns before the mind is capable of dealing with such issues.
Acquiring specialised knowledge in various domains (history, geography, the arts).	Potentially habit-forming.
Improving language skills both for second language acquisition and for native speakers.	May be expensive to develop and require highly skilled staff.
Presenting cultural heritage collections in a new manner to a wide audience.	
Can be good topic for social contacts.	Excessive use can stunt social development.
Content is essential: could lead to acquisition of new knowledge.	Content is essential: there is a risk of misinformation through inaccurate subject material.
Enjoyment, which is increasingly important as the pace of life increases.	

It is essential to bear in mind that heritage games need to find a niche market. Heritage institutions cannot compete with the games industry by each year releasing new games with increasing degrees of excitement and sophistication. Games look tired very fast, and it is therefore essential that the underlying concepts are as robust as possible.

Introducing the Technology

Before development

The complexity of the games industry and product development would make it necessary for cultural heritage institutions to partner with a game development company if

they wish to develop a marketable application. Before beginning work on a game, the following issues should be carefully addressed and contemplated:

- How clear is the game concept? How much background work remains to be done on the interface, content, and development environment?
- How clear is the incorporation of historical details into the game, and if it involves presentation of a building or a collection of items, what preparatory work has already been done? How familiar is this topic to the target audience and will the 'Help' information and accompanying documents be sufficient to foster an understanding of the cultural setting? Would they point the way to further study?
- What distinguishes this game from other products from the same genre?
- Is the underlying technology clear?
- What is the platform – PC, console, or some other device? Would this game be used in the cultural institution only or would it be widely sold or disseminated? Bear in mind that heritage software is likely to be a niche market with a narrow potential user base although this may reflect the fact that the heritage sector has not yet addressed the marketing issues.
- How is your development team composed? Is the team experienced, or will this be the first time they have worked together? Have its members got all the necessary skills?
- What is the highest graphical standard realistically attainable? Modern quality is a crucial factor for widespread acceptance of a game.
- Are there copyright or intellectual property rights (IPR) management issues?
- How intuitive is the proposed user interface?
- What sound effects and audio will be used? Are these consistent with the historical period?

During development

Since most cultural heritage institution are likely to work with external developers, there are key questions which should be clearly communicated to the developers, negotiated in detail, carefully tracked during development, and monitored for compliance and rigour afterwards:

- What exactly must be done? The game has to be defined in detail, including the number of levels, storyboards, menu screens, sound effects and other factors.
- One specific feature for cultural heritage related games development is the presentation of artefacts and historical background. What innovative ways can be used to incorporate these into a game? How will the historical facts be put across if the game involves unexpected events? The study of primary sources could be a time-consuming and labour-intensive task.
- How will the team be organised and what is the overall timeframe? How many artists, designers, programmers, historians will participate? A formal presentation of their tasks such as a Gantt chart or Pert diagram will be necessary. All team members will need detailed schedules for their work.
- What digitisation work will be necessary for presentation of the historical artefacts?
- What resources are needed? Does the game developing company or the organisation have all of the necessary equipment, including the hardware and software necessary for digitisation?

A joint committee, involving staff from the heritage organisation and the partner developers, is one possible organisational structure which could be put into place to work in monitoring and overseeing the game development process. It is essential to maintain control on the schedule and the required outcomes and deliverables. This will require good preliminary planning with clearly defined milestones, success criteria and a thorough identification of possible risks.

Potential difficulties

For the cultural heritage sector, more so than any other faction of the gaming world, specific needs will be to bring together and verify all of the specific data which might relate to history in general, history of everyday life, or written culture that will feature in the game. If items from collections are to be incorporated, it may be necessary to organise their accurate and efficient digitisation and description. The proper presentation of artefacts and historical material together with relevant background information may be time-consuming and labour-intensive. Another issue which may cause problems is that of copyright and IPR management. These should be investigated thoroughly prior to beginning the project.

Appendix I – Comparison of Consoles

Console / Parameter	Microsoft Xbox	Sony PlayStation 2	Nintendo GameCube	Sega Dreamcast	Nintendo Game Boy Advance
CPU Type	Modified Intel Pentium III	128-bit 'Emotion Engine'	'Gekko' IBM Power PC	64-bit Hitachi SH-4	32-bit CPU developed by ARM Ltd.
CPU frequency	733 MHz.	300 MHz.	485 MHz.	200 MHz.	16 MHz.
Bus transfer rate	6,4 GB/sec.	3,2 GB/sec.	2,6 GB/sec.	800 MB/sec.	
FPU co-processor	No	Yes	No		
Graphics Type	Custom nVidia 3-D chip	'Graphics Synthesizer'	'Flipper' ATI graphics chip	128-bit NEC PowerVR 2DC	2.9-inch LCD 240x160 resolution
Graphics frequency	250 MHz.	150 MHz.	162 MHz.	100 MHz.	
Polygons/sec.	125 million	75 million	12 million	3 million	
HDTV capable	Yes	No	No	No	-
Embedded cache	No	Yes	1 MB texture cache		
Graphics RAM		4 MB VRAM	3 MB Mosys 1T-SRAM	8 MB VRAM	96 KB VRAM
RAM	64 MB	32 MB RDRAM	40 MB	16 MB	32K
Removable memory	8 MB card	2 memory slots	2 memory slots		
Audio	Custom 3D-audio	SPU2 (+CPU), 48 channels, 2MB RAM	Special 16-bit DSP, 64 channels	45 MHz Yamaha DSP, 64 channels, 2MB RAM	PCM stereo sound generator
Game medium	Proprietary 4.7-GB DVD	Proprietary 4.7-GB DVD, original CD's	Proprietary 1.5-GB optical disc	Proprietary GD-ROM (Gigabyte Disc, 1,2 GB)	
MCP – Media comm.processor	Yes				
Network	10/100-Mbps Ethernet Broadband	Drive bay available		Broadband network	
Modem	56 K (optional)			56 K	
Controller	4 game ports	2 ports	4 game ports, wireless controller	4 game ports, analogue joystick	

Console / Parameter	Microsoft Xbox	Sony PlayStation 2	Nintendo GameCube	Sega Dreamcast	Nintendo Game Boy Advance
In-built HDD	8 GB	Drive bay available			
DVD-Drive	5X DVD drive				
FireWire port	No	Yes			
USB Port	No	2 ports			
AV- outputs			Analogue & digital		
Optical digital output	No	Yes	No		
Expansion port	Yes		2 serial, 1 parallel	2 ports for memory cads, tremor pack or Visual Memory	
Approx. Price	$200	$200	$150	Discontinued, though still available second-hand	$70
Approx. available games	50 proprietary titles	Over 300	100 proprietary titles		100 proprietary titles; also compatible with games for original Game Boy
Notable games	Splinter Cell, Timesplitters 2, Halo	Grand Theft Auto: Vice City, Tony Hawk's Pro Skater, Metal Gear Solid 2, The Getaway, Tekken 4	Super Mario Sunshine, Luigi's Mansion, FIFA 2003	Soul Calibur, Sonic Adventure, Phantasy Star Online, Unreal Tournament, Ecco the Dolphin	Castlevania, Super Street Fighter II, Tekken Advance, Doom, Super Mario Kart

Annexes

Selected Glossary

Term	Meaning	Appears in the Section(s) on:
Anti-collision	A general term for methods of preventing the cross-interference of radio waves from several devices, thus enabling the simultaneous reading of more than one tag by the same reader	Smart Labels & Smart Tags
Audio card	Additional hardware which improves the standard audio capabilities of a PC	Games Technology
Augmented reality	Overlaying a real or photorealistic view with virtual reality models	Virtual Reality & Display Technologies, Human Interface Issues
Auto-ID centre	Non-profit collaboration between private companies and the Massachusetts Institute of Technology that is investigating the development of an Internet-like infrastructure for tracking goods globally through the use of RFID tags	Smart Labels & Smart Tags
Avatar	The representation of a human user or computer-generated actor in a virtual world	Smart Labels & Smart Tags, Virtual Reality & Display Technologies, Games Technology
Bespoke	An application tailored to meet the specific needs of the customer	Customer Relationship Management
Data mining	Discovering past trends that may lead to potential future opportunities	Customer Relationship Management
DirectX driver	Software assisting Microsoft's DirectX, a Windows technology that enables higher performance in graphics and sound when playing games or watching video on a PC	Games Technology
Field programming	Programming information into a tag after it has been shipped from the manufacturer to a customer or end user, usually occurring before the tag is installed on the object to be identified	Smart Labels & Smart Tags
Game controllers	The interface with which users control their progress in a game. An example is the PlayStation dualshock controller	Games Technology

Term	Meaning	Appears in the Section(s) on:
Graphics card	Additional hardware which improves the standard graphical capabilities of a PC	Games Technology
Haptics	Physical devices employing force-feedback to give users the impression of actually touching/ manipulating a virtual object	Games Technology, Human Interface Issues
Inductive coupling	A method of transferring data or power between RFID tags and readers based on inducing a current in a coil (or antenna)	Smart Labels & Smart Tags
Integrated circuit (IC)	A micro-electronic semiconductor device consisting of many interconnected transistors and other components	Smart Labels & Smart Tags
Lenticular	Changing appearance as light reflects at different angles	Smart Labels & Smart Tags
Metadata	'Data about data', often crucial background information	Digital Asset Management
Modulation	Method of transmitting data converted into digital form based on the change of the frequency or amplitude of a wave	Smart Labels & Smart Tags
Multimodal	Simultaneously stimulating a number of human senses	Human Interface Issues
Multiple access schemes	A general term for methods of increasing the amount of data that can be transmitted within the same frequency spectrum. Typically RFID readers use Time Division Multiple Access (TDMA), meaning they read tags at different times to avoid interfering with one another	Smart Labels & Smart Tags
Off-the-shelf	A 'one-size-fits-all' solution, primarily useful for small-to-medium sized enterprises	Customer Relationship Management
Plug and play	Self-configuring technology, requiring only minimal effort from the user	Customer Relationship Management
Semi-passive tag	Tags where the battery is used to power the microchip's circuitry but not to communicate with the reader	Smart Labels & Smart Tags
Shutterglasses	A stereoscopic visual interface displaying a slightly different image to each eye in rapid succession, thus providing an illusion of three-dimensionality	Human Interface Issues
Web-crawler	A program which automatically navigates its way around the Web, gathering content from Web pages	Digital Asset Management
WebDAV	Web-distributed Authoring and Versioning, a set of extensions to HTTP which allows users to edit and manage files collaboratively on remote Web servers	Digital Asset Management

ABBREVIATIONS

Abbreviation	Stands For	Appears in the Section(s) on:
3D	Three-Dimensional	Virtual Reality & Display Technologies
API	Application Programmer Interface	Virtual Reality & Display Technologies
AR	Augmented Reality	Virtual Reality & Display Technologies, Human Interface Issues, Games Technology
ASP	Application Service Provider	Customer Relationship Management, Digital Asset Management
ATM	Automated Telling Machine	Human Interface Issues
AVI	Audio-Video Interleave	Games Technology
CAD	Computer Aided Design	Virtual Reality & Display Technologies
CAT	Computerised Axial Tomography	Human Interface Issues
CAVE	Cave Automatic Virtual Environment	Virtual Reality & Display Technologies, Human Interface Issues
CCTV	Closed-Circuit Television	Smart Labels & Smart Tags
CPU	Central Processing Unit	Games Technology
(e)CRM	(Electronic) Customer Relationship Management	Customer Relationship Management, Digital Asset Management
CRT	Cathode Ray Tube	Human Interface Issues
CTI	Computer Science, Telecommunication and Information systems	Customer Relationship Management
DAM(s)	Digital Asset Management (system)	Digital Asset Management

Abbreviation	Stands For	Appears in the Section(s) on:
DBMS	Database Management System	Customer Relationship Management, Digital Asset Management
DVD	Digital Versatile Disc	Games Technology
EAD	Encoded Archival Description	Digital Asset Management
EAN	European Article Numbering	Smart Labels & Smart Tags
EAS	Electronic Article Surveillance	Smart Labels & Smart Tags
ECC	Error Correcting Code	Smart Labels & Smart Tags
EEPROM	Electrically Erasable Programmable Read Only Memory	Smart Labels & Smart Tags
EPC	Electronic Product Code	Smart Labels & Smart Tags
ESRB	Entertainment Software Rating Board	Games Technology
FAQ's	Frequently Asked Questions	Customer Relationship Management
GPS	Global Positioning System	Games Technology
GUI	Graphical User Interface	Human Interface Issues
HCI	Human Computer Interaction	Human Interface Issues
HMD	Head-Mounted Display	Human Interface Issues
HTML	Hypertext Markup Language	Digital Asset Management, Virtual Reality & Display Technologies
HTTP	Hypertext Transfer Protocol	Digital Asset Management
IC	Integrated Circuit	Smart Labels & Smart Tags
IM	Instant Messaging	Customer Relationship Management
IPR	Intellectual Property Rights	Games Technology

Abbreviation	Stands For	Appears in the Section(s) on:
ISAD(G)	International Standards Archival Description - 2nd edition	Digital Asset Management
ISO	International Organization for Standardization	Smart Labels & Smart Tags
LAN	Local Area Network	Human Interface Issues
LCD	Liquid Crystal Display	Human Interface Issues, Games Technology
LEP	Light-Emitting Polymer	Human Interface Issues
LOB	Line Of Business	Customer Relationship Management
MARC	Machine Readable Catalogue	Customer Relationship Management, Digital Asset Management
MMOG	Massive Multiplayer Online Game	Games Technology
MPEG	Motion Picture Experts Group	Virtual Reality & Display Technologies, Games Technology
MR	Mixed Reality	Virtual Reality & Display Technologies, Games Technology
MSP	Managed Service Provider	Customer Relationship Management
NTSC	National Television Standard Committee	Games Technology
OLED	Organic Light-Emitting Diode	Human Interface Issues
ODBC	Open Database Connectivity	Human Interface Issues
OpenGL	Open Graphics Library	Virtual Reality & Display Technologies, Games Technology
PAL	Phase Alternation Lines	Games Technology
PDA	Personal Digital Assistant	Customer Relationship Management, Human Interface Issues, Games Technology

Abbreviation	Stands For	Appears in the Section(s) on:
QTVR	QuickTime Virtual Reality	Virtual Reality & Display Technologies
RAM	Random Access Memory	Smart Labels & Smart Tags, Games Technology
RDF	Resource Description Framework	Digital Asset Management
RFID	Radio Frequency (Identification)	Smart Labels & Smart Tags
RM3D	Rich Media 3D	Virtual Reality & Display Technologies
ROI	Return On Investment	Customer Relationship Management, Digital Asset Management
ROM	Read-Only Memory	Smart Labels & Smart Tags, Games Technology
RPG	Role-Playing Game	Games Technology
R/W	Read/Write	Smart Labels & Smart Tags
SDK	Software Development Kit	Digital Asset Management
SME	Small-to-Medium sized Enterprise (fewer than 250 employees)	Customer Relationship Management
TDMA	Time Division Multiple Access	Smart Labels & Smart Tags
UCC	Uniform Code Council	Smart Labels & Smart Tags
UPC	Universal Product Code	Smart Labels & Smart Tags
USB	Universal Serial Bus	Human Interface Issues
UWB	Ultra Wide Band	Smart Labels & Smart Tags
VDU	Visual Display Unit	Virtual Reality & Display Technologies
VE	Virtual Environment	Human Interface Issues

Abbreviation	Stands For	Appears in the Section(s) on:
VR	Virtual Reality	Virtual Reality & Display Technologies, Games Technology
VRAM	Video Random Access Memory	Games Technology
VRML	Virtual Reality Modelling Language	Virtual Reality & Display Technologies, Games Technology
WAN	Wide Area Network	Human Interface Issues
WAP	Wireless Application Protocol	Customer Relationship Management
WebDAV	Web-based Distributed Authoring and Versioning	Digital Asset Management
WIMP	Windows Icons Mouse Pointer	Human Interface Issues
WORM	Write Once/Read Many	Smart Labels & Smart Tags
WYSIWYG	What You See Is What You Get	Virtual Reality & Display Technologies, Games Technology
X3D	Extensible 3D	Virtual Reality & Display Technologies
XML	Extensible Mark-up Language	Customer Relationship Management, Digital Asset Management, Smart Labels & Smart Tags, Virtual Reality & Display Technologies

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FastPoint: http://www.ftgdata.com
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Brain actuated control

Words +: http://www.words-plus.com/

Speech- actuated control
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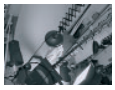

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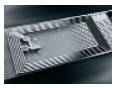

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