1 Has archaeology remained aloof from the information age?

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1.1 Introduction

The 'Information Age' has been marked by substantial and continuing increases in computer processing power, by the convergence of computing and telecommunications, and latterly by convergence with mass entertainment. One of the major benefits of these developments has been the potential for the dissemination of information via the now widespread high speed networks and easily distributed media such as CD-ROM. The use of such techniques as multi-media, hyper-media and virtual reality have made this information more accessible to its users. A glance through the daily papers is sufficient to show that these developments are not merely of interest to computer specialists and business, but will effect all areas of society, both at work and at home (e.g. Freedland 1994).

This paper reviews overall developments in information technology over the last ten years, and examines how such techniques have been used for the dissemination of archaeological information. Developments in the related areas of libraries and museums are also described. In conclusion it is argued that whilst these techniques are beginning to be used for the dissemination of archaeological information, the profession as a whole still aspires to conventional publication in a monograph or journal. It is suggested that this cannot be healthy for a discipline which depends so much on public support, and which has so much potential to enrich people's lives.

1.2 Information technology

The last decade has seen very substantial developments in computer hardware and software, with perhaps the most significant change being the increase in computing power available to users. In the early 1980's the maximum generally available configuration consisted of an S100 bus based machine with a Z80 chip, 64K RAM, a 5Mb hard disk and a 100K floppy disk drive, using the CP/M operating system. Such a system would cost several thousand pounds. This standard was superseded by the IBM PC and its imitators – the Intel 8086 and 8088 based family of microcomputers, with the MS-DOS operating system. A typical configuration consisted of 640K RAM, a 20Mb hard disk and a 360K floppy disk drive, at a similar cost to the CP/M machines. The arrival of Alan Sugar's AMSTRAD range of IBM compatible computers in 1987 brought the cost of such a system down to under a thousand pounds, although the overall standard of the equipment in terms of screen, keyboard and durability was not considered by many to be suitable for business use. However other manufacturers quickly followed suit, and provided full specification microcomputers for a similar outlay. This order of cost (a thousand pounds) has subsequently remained the stable norm for the base configuration, despite inflation and very substantial increases in specification. A typical microcomputer now has an 80486 processor, 8Mb RAM, a 130Mb hard disk and a 1.4Mb floppy disk drive. Whilst MS-DOS has continued to evolve, the Windows operating system is now the standard. It is likely that a 600Mb CD-ROM drive will become usual in the near future as a means of importing software and data, and when writable CD-ROM drives reduce in cost sufficiently, these will become established as a slow but permanent backup and storage medium (Hyon 1994). In parallel with developments in the Intel arena, Apple computer have been providing systems based on the Motorola 68000 series of processors. After the demise of the Apple II, the shortlived Lisa was followed by the Macintosh family, characterised by their 'Windows, Icons, Mice and Pull-down menu' (WIMP) interface, developed from earlier work by Xerox. Apple microcomputers have a significant following in the graphics, publishing and educational sectors, but have not captured more than about ten percent of the overall market for personal computers. The Apple Power-Mac now provides compatibility with MS-DOS machines (Sheldon *et al.* 1992), but there is a penalty to be paid in terms of speed and the amount of memory which is required, and therefore the cost of an effective system is higher than for the equivalent IBM compatible PC.

Multiple access to computers, peripherals and data is provided either through multi-user access to a single system, or through the connection of multiple servers, peripherals and users via single or linked networks. Multi-user access to microcomputer facilities was provided in the early 1980's through the use of the MP/M operating system running on one of the Z80 family of microcomputers, and latterly with the introduction of 16-bit processors running Concurrent CP/M-86. For computers in the mini-computer class there were a range of proprietary operating systems, with Unix beginning to be quite widely used on machines of this scale. For the 80x86 family of processors Xenix (a version of Unix specifically developed for this platform) was introduced as a multi-user alternative to the standard MS-DOS. As an alternative OS/2 provided multi-tasking. Perhaps because of the significant memory and other resources required for its implementation, OS/2 was not initially widely used except for specialist applications, such as building management systems, and network management, where it's multi-tasking, and graphical interface were especially appropriate. Despite the promise of OS/2, MS-DOS and latterly Windows have remained the *de facto* standard for single user PCs, with Unix as the standard for multi user platforms at the PC and mini-computer scale.

Local area networks provide an alternative means of achieving shared access to central (and distributed) facilities. Up until the late 1980's there were a range of proprietary network systems, offering facilities from simple file and message transfer to access to central servers. Currently the most widely used network protocol is TCP/IP, a broadcast protocol using physical cabling conforming to a bus topology. A sizeable minority of networks use the Token Ring protocol, which as its name suggests employs token passing on a ring topology. Cabling technology has evolved from thick and thin ethernet to a structured approach, typically consisting of a mixture of unshielded twisted pair (UTP), and fibre-optic. UTP is now usually operated at a speed of 10 megabits (Mb) per second, but speeds of 100Mb are claimed by suppliers. Fibre-optic cable can transmit at speeds of 140Mb for FDDI (Fibre Distributed Data Interface), and higher for methods such as ATM (Asynchronous Transfer Method). These higher speeds are particularly relevant where the large volumes of data required for high resolution images and moving images need to be moved over the network. For smaller networks, servers employing the Novell Netware operating system have become the norm. Typically these are based on an 80x86 platform, with most mainstream MS-DOS packages having Novell versions. Novell is an obvious choice for small networks, typically growing to a maximum of tens of users, although the ability to satisfactorily support larger numbers is claimed by the manufacturers, and Netware version 4.x addresses the requirements of multi-site installations. Several small Novell networks can be linked together. For larger networks, particularly spread across wide-area communications, Unix servers are more often used, with TCP/IP as the network protocol. Typically Netware involves larger quantities of data being transferred over the network, whilst the Unix based networks more usually operate in a mode which imitates terminal access: the 'client-server' model, which optimises traffic on the network and utilises local processing power. It has been available for some time, although many applications developers remain shy of it. A networked version of Windows (Windows-NT) is also available; it may become commonly used in the longer term (and is already presenting a challenge to Unix), but it has yet to be widely adopted (Yager & Smith 1992). Apple microcomputers can access both Novell and Unix servers via a range of protocols, and also have Appletalk, their own integral but rather rudimentary networking capability.

Over this period there have been considerable advances in wide area networks, both in terms of what is provided by utilities such as British Telecom and Mercury for public use, and what is available via the academic networks. In the early 1980's connections supplied by British Telecom included a range of leased lines, which were expensive in terms of the capacity provided, and therefore out of reach of most museums and archaeological bodies. Modem use of dial-up lines (mostly analogue links throughout) was possible, but these were not very reliable. EPSS (the Experimental Packet Switching Service) allowed modem access to a high capacity link which became more reliable through time and evolved into PSS.

Today a range of leased lines (at low and high speeds) are available, together with the dial-up PSS service. ISDN2 (Integrated Services Digital Network Version 2) service from British Telecom provides dial-up access to lines of almost limitless capacity, thus enabling the bandwidth of the link to rise in order adapt to the volume of data being carried. Because of the potential for unplanned costs, ISDN lines tend to be utilised for occasional use (particularly for high bandwidth purposes such as video conferencing), as backup to fixed links, or where the overall anticipated data volumes are low. However, lower costs may lead to more widespread use (Andrews 1994). Except for the final link from the network to the subscriber, these connections are now entirely provided through digital networks with a high degree of reliability. For the higher bandwidth services (typically from 64K upwards) the carriers fibre-optic network is extended so as to connect directly to the customers network. Connection costs to 64K plus networks are therefore high, but the absence of a copper based analogue component facilitates high data transmission rates.

Up until recently JANET (the Joint Academic NETwork) provided a comprehensive but relatively low speed link between academic institutions in the United Kingdom, and via the Internet to the rest of the world. In the past archaeologists and museums were discouraged from accessing JANET, as it was felt that they would overload it with unscholarly data. The newly available SuperJANET offers a much higher bandwidth, enabling larger volumes of data to be transmitted. It is debatable for how long this very high capacity will remain unsaturated. However in the short term its use by museums and others who are able to utilise it for image transmission and other high volume activities is being encouraged. The majority of the academic centres in the United Kingdom now have access to SuperJANET, and elsewhere in the world high bandwidth networks are being developed.

The various forms of optical storage technology, including particularly CD-ROM, are an alternative to wide area communications for the distribution of large quantities of data, and are often used for encyclopedic works. This medium is particularly suitable for circumstances where a large volume of data which changes relatively slowly needs to be disseminated. It is a complimentary method to network communications, as it allows desktop access to very large amounts of data (perhaps networked locally), but is not dependent on wide area connections.

Technological improvements in processor speed, and in memory, storage and network capacities, have facilitated the widespread use of image based and graphical facilities which had previously been prohibitively expensive. A wide range of means of display and access are facilitated by the ability to display images through an interactive interface which allows users to browse through data in a number of ways. The whole gamut of multimedia includes text, images (still and moving), and sound. In the users imagination the term 'multimedia' usually conjures up all of these, but in practice a simple combination of images and text is more common. This is termed 'interactive' if the user has a choice of routes through the data. Hypertext permits a range of links to be made between related records, rather than the straightforward index or sequential access, leading to serial progress through the data, which has up until recently been the norm (Morrill Tazelar 1988). Much has been made of the potential of virtual reality, perhaps largely because the idea of becoming immersed and navigating through a computer generated environment appeals to the imagination. In practice the first applications were constrained by the very substantial computing power required to manipulate a three dimensional virtual world, and the limitations of sensors and display technology. Both technology and expectations have now matured. In addition to some quite sophisticated games consoles, virtual reality now has a range of practical applications including architectural simulations, military training, medicine, and telecommunications network management (Peltu 1994). It has much potential as a means of providing a means of navigating through the electronic sources contained in the 'virtual library', which is already beginning to replace traditional paper resources.

There has been a substantial growth in the availability of packaged software for both personal computers (IBM compatible and Macintosh), and larger systems (Picher *et al.* 1987). Such products range from commonly used applications such as word processors, databases and spreadsheets, to a whole gamut of programs for particular industries, and a wide range of utilities. Typically a single suite of programs will provide the functionality of word processor, spreadsheet, database and diary, or these can be obtained through linked packages. Flexibility and integration are some of the advantages from these products, which in most cases have removed the need for special programs to be written either by or for the user. Although in many ways an extension of word processing, desktop publishing was hailed as a new and powerful technology (Seybold 1987), and has provided an effective means of producing copy, either for direct printing from a laser printer, or for reproduction by more conventional technology.

An important development which was foreshadowed before the microcomputer revolution, but has nevertheless matured during this period, is the convergence of telecommunications and computing, leading to the present situation where almost all the telecommunications in the developed world use digital technology for data transmission, and computerised digital exchanges have replaced the electromechanical technology which had its roots in the 19th century. Following on from the convergence of computing and telecommunications, there is now a convergence of telecommunications and entertainment technologies. In competition with terrestrial television, and the later satellite services, high speed digital networks are being installed to enable entertainment to be broadcast to domestic users. In the United Kingdom entertainment providers are installing their own networks, and in the United States there have been well publicised moves by the entertainment providers to purchase communications corporations. In the United Kingdom legislation prevents British Telecom from transmitting television and video over their network, but similar legislation in the United States is presently being relaxed, and trials to test the transmission of video over the present copper telephone network have proved encouraging.

Standards have become important in facilitating the interconnection of equipment and applications, and in allowing users to select hardware and software from a range of suppliers. Throughout much of the 1980s, standards in the computing and telecommunications industries varied widely. In many areas there was little commonality between products, and some of the larger suppliers supported several incompatible standards within their own product range. This situation tended to work to suppliers' advantage, as once a user was committed to a particular range of equipment, it was necessary to continue purchasing both hardware and software from a limited source, and it was necessary to replace the whole installation if a change was required.

One of the most significant developments in standards has been the established of the OSI (Open Systems Interconnection) standard, which specifies seven levels of standard for data communication. This *de jure* standard, has particularly been sponsored by the United Kingdom and United States Governments. In practice the full OSI standard is not often implemented, but it has nevertheless had a big effect on the development of a suite of *de facto* standards, which include ethernet networking, and hardware and software using the Unix operating system. Pragmatically MS-DOS, Windows and Novell tend to be included within this environment. As a consequence for smaller multi-user computers, through the size range traditionally occupied by minicomputers, up to smaller mainframes, this combination of Unix and ethernet is widely used, permitting an extensive range of suppliers equipment and software to be used together. At the smaller end of the scale the MS-DOS and latterly the Windows operating systems have become the standards, together with Novell for networking. Apple has (with the exception of unauthorised far-eastern clones) maintained control of its own standards, so this significant, minority constituting about ten percent of the installed base of personal computers, remains homogeneous in its conformance to the manufacturers standards.

A further range of standards have emerged for the specification, implementation and maintenance of computer systems. The United Kingdom government has been a major force behind this, through the CCTA (formerly the Central Computing and Telecommunication Agency, now the Government Centre for Information Systems), which has encouraged the establishment of a range of methodologies such as SSADM (Structured Systems Analysis and Design Methodology), PRINCE (Projects IN Controlled Environment), GOSIP (Government Open Systems Interconnection Profile), CRAMM (Computer Risk Analysis and Management Methodology), to name some more prominent examples (CCTA 1989a, 1990a, 1990b, 1991a, 1991b). Many of these provide a codification of industry best practice, and together they provide an overall set of linked methodologies.

1.3 Libraries

Since the 1960's there has been an appreciation of the potential for computerised library catalogues. The initial model consisting of a printed catalogue and index to holdings (perhaps on microfiche) is now being replaced by an on-line catalogue, accessed within the library, and perhaps accessible externally as well. Computers are also used for a range of management purposes in libraries, and in particularly for stock control and circulation management. Recently the emphasis has switched away from merely providing an index to paper information, to making the sources themselves available electronically. A range of facilities for searching both locally held and remote data, and for electronic document delivery, are now routinely expected by users. This growth in the facilities provided by libraries has been matched by the production of electronic information sources, available on CD-ROM and via networks. A controversial development is the tendency towards the rapid dissemination of papers by network, thus avoiding the sometimes lengthy process of peer review. Copyright issues are also a concern. The scientific community has been in the forefront of such developments, but others are following. Developments in the nature of scientific communication are described by Meadow and Buckle (1992), who argue that the major change is in the increase of informal communication, much of it facilitated by network technology.

Most of the larger science publishers are developing databases of electronic journals, together with electronic products in the serial and textbook areas. In the United States, as Gelfand and Booth (forthcoming) have described, there have been several initiatives which have used these techniques, including, CORE (Chemistry On-line Retrieval Experiment) compiled by the American Chemical Society at Cornell University; the Red Sage Project at the University of California, San Francisco sponsored by Springer-Verlag; TULIP, promoted by Elsevier, with 15 campus sites worldwide; and various joint ventures initiated by OCLC (On-line Catalogue of the Library of Congress) and the AAAS (American Association for the Advancement of Science), including the On-line Journal of Current Clinical Trials.

A range of reports and initiatives have underlined the importance with which these developments are viewed in Britain. The Follett Report (Joint Funding Councils 1993) has addressed the needs of academic libraries, and has made recommendations aimed at providing access to the facilities which library users will expect to be available, and at taking advantage of opportunities presented by new technologies. A study conducted in 1992–93 by the Royal Society, the British Library and the Association of Learned and Professional Society Publishers (Royal Society 1993), aimed to learn how publishers, information intermediaries and user's aims are being met, and what gaps there are in meeting these actual and anticipated needs. The British Library has recently launched a range of initiatives of on-line data access and document delivery. That these concerns are not just a matter for information professionals and academics is shown by the recent white paper published by the United Kingdom Government on science and technology (UK 1993), and a further document published by the United Kingdom government on the information superhighway (CCTA 1994). In the United States the National Academy of Sciences has produced *Science, Technology and the Federal Government: National Goals for a New Era*, (National Academy of Sciences 1993), and there are several other relevant reports (National Science Foundation 1990; Gould and Pearce 1991). New American federal legislation, such as the Boucher Amendment (USA 1993) is intended to encourage the development of a national data 'Superhighway'.

1.4 Museums

Perhaps because of an inherent conservatism, or because of the dichotomy between their roles as 'cabinets of curiosities' and 'centres of information' (Stewart 1984), museums have in general lagged behind libraries in the application of new technology. There has nevertheless been a lengthy history of electronic cataloguing for museums (Lewis *et al.* 1967), dating back to the 1960s with the formation of IRGMA (the Information Retrieval Group of the Museums Association), the forerunner of the MDA (Museum Documentation Association). Initial work was aimed at assessing the practicality of using this new technology, at developing standards for the data to be stored, and at developing a range of cards and forms for data capture. The main purpose of such initiatives was seen as assisting in the production of a detailed catalogue of the museum's collections. This emphasis on cataloguing continued into the 1980's, when partly in response to critical reports by the National Audit Office (NAO) and others (UK 1988, 1989), collections management, and in particular accountability, took on greater importance (Booth 1985; Roberts 1988). However, whilst effective management of collections and resources have remained a priority, the emphasis has now switched to public access and visitor satisfaction. Museums must continue to manage their collections in an accountable manner, but this is not an end in itself. The change in emphasis from collections management to public access was marked by the 1989 MDA conference on *Sharing the Information Resources of Museums*, and by the 1993 conference, which specifically addressed museums use of interactive multimedia (Roberts 1992; Lees 1993). The

LASSI (Larger Scale Systems Initiative) project, a collaborative venture aimed at specifying and procuring a software package for museums, is illustrative of this trend. It sits astride the change in priorities, having been conceived as an aid to collections management, but with an increasingly important public access component.

Whereas libraries, which are suppliers of information and have an increasing dependence on technology for information delivery, have seen information systems as strategic in terms of McFarland and McKenny's grid (McFarland & McKenny 1983), museums have tended to perceive information technology as merely providing support to their principal activities. The model which can be applied to museums is similar to that argued for the humanities in general. There is considerable potential for the use of information technology, but in contrast to other disciplines such as the sciences and social sciences, where this potential has already been recognised, it is yet to be realised (J. Paul Getty Trust 1993; British Library Board and British Academy 1993; Michelson & Rothenberg 1992). However museums are now attaching increasing importance to this area. An example is the Science Museum in London, where automation originated in the Library, but with Information Systems administrative relocation to the Resource Management Division, which also contains finance, human resources and estates, the strategic importance of information systems has been recognised (Booth in press).

The overall trend in information systems at large, which is being followed by museums, is one of decentralisation in terms of both systems and organisation, with priorities in information systems being determined by the users, as they come more to control the facilities which they utilise. Users in the broadest sense are now negotiating service level agreements with systems providers, and are aiming to obtain a consistent service according to agreed parameters (CCTA 1989b). The trend for decentralisation, coupled with greater user sophistication, is leading to a movement of staff away from the central information systems providers. Whilst one outcome of these changes is for service providers to be located nearer to the users they support, this arrangement can lead to difficulties in maintaining institution wide data and technical standards, although one product of the introduction of such a network is likely to be a strengthening of standards. Paradoxically, because of the technical complexity of the infrastructure, the introduction of more sophisticated networks is likely to lead to an increase in the numbers of central support staff. With an appreciation of the strategic importance of information, the institution-wide network can acquire additional importance and resourcing.

Several large museums have carried out a strategic review of their information systems needs. These studies have tended to stress the potential of networking for both internal and external communication, and the role to be played by such new technologies as multimedia (Smithsonian Institution 1992; Booth in press; Lees & Booth 1993).

Many museums now have the facilities to make available images as well as text describing the items in their collections. These include the National Museum of Denmark, where a pioneering project has stored images in analogue format on a video disk, and more recent initiatives employing digital storage at the Design Museum in London, where the entire collection is available through a hypermedia application (Rubinstein 1992), and the National Railway Museum, York, where the large holdings of glass photographic negatives are being digitised (Heap & Booth 1993). The Micro Gallery at the National Gallery in London has digital images for almost all of the entire collection of over 2,000 paintings. With the widespread use of video technology, and increasingly common use of digital methods, the public now expect to see images as well as text. It is arguable that in a museum context, a text only OPAC application such as that at the Department of American Art at the Metropolitan Museum of Art, New York (Hoover Voorsanger 1992), would not now be acceptable to the public.

Kodak's Photo-CD has set the standards for digital images (Chen 1993), but still lacks the necessary database support for manipulating the very large numbers of images which many museums have. However the range of formats which can be scanned continues to be enlarged, and work by those such as Luna Imaging Inc. (Dr. Michael Ester *pers. comm.*) is developing links between Photo-CD and conventional text databases. Interactive exhibits allow the public to manipulate image, text and sound, and perhaps also to touch real objects. This 'touch and feel' experience became widespread in children's museums in the late 1970s, some of the ideas having been prototyped in the Children's Gallery at the Science Museum in London in the 1930s. An example of such an interactive approach is the natural history discovery centre at the Liverpool Museum; a similar facility for science is planned for the new education centre at the Science Museum in London. The potential of multimedia has been explored in a research report from the British Library by Signe Hoffins (Hoffins 1992), although multimedia was not at that time felt to be a mature technology (Arts Council of Great Britain 1992). A project at Loughborough University is examining means of linking the traditional structured database most often used for museum documentation, with an interactive hypermedia interface which would be suitable for public access (Poulter *et al.* 1994).

CD-ROM is being explored by museums as a means of distributing information, and Chadwyck-Healey Ltd have been particularly prominent in this area (Chadwyck-Healey 1992). CD-ROM provides a very significant advance on microfiche, and is likely to become a successful means of distributing museum's data to a wide public. Whilst there have been some successful implementations of centralised databanks (for instance the Canadian Heritage Information Network – CHIN, and the FENSCORE natural science collaborative database (McGee 1992; Pettit 1992), it seems likely that network access to databases located in their host museums will provide users with a 'virtual database', which has the characteristics of the union databases which have been sought for so long. Users will thus be able to access a much larger collection of information than is actually present at a single location.

Several museums are now implementing networking strategies. The potential range of different approaches is illustrated by the South Kensington Museums in London. The Natural History Museum has recently installed a comprehensive network infrastructure, to which all of the staff in the museum may be connected. The first priority was to provide access by scientists to external databases and messaging facilities, but the museum is also providing for internal and external users access to its own databases. Use of the network for internal electronic mail grew surprisingly quickly in the few months after the network became available. The Science Museum installed a comprehensive network at its three main sites and storage facilities early in 1994. Initially the priority was to make major internal databases available to staff, and to foster synergy through internal communication; but access to external data sources is likely to become important, particularly as other museums data resources become accessible via JANET and the Internet. It is planned to also make the museum's information resources available to external users. The Science Museum's Library holdings are already available to external users via the Libertas computer system operated by Imperial College. The Victoria and Albert Museum is pursuing a policy of incremental networking, which will provide shared access for workgroups, and via bridges, access to central facilities and external services. Access to JANET is available to these museums in South Kensington via Imperial College, and there is a proposal to link the South Kensington Museums to SuperJANET via an optical fibre 'ring', connected to the Imperial College SuperJANET node. Imperial College was selected as one of 5 introductory test sites for installing SuperJANET. Whilst these three museums with different collecting areas are pursuing networking from different perspectives, the eventual result will be comprehensive internal networking, with access to and from the outside world. The links to SuperJANET make possible the transmission of large volumes of data including images. Similar efforts are being made among the museums and libraries of the Smithsonian Institution in Washington DC (Smithsonian Institution 1992), and others (Wallace & Jones-Garmil 1994).

There are a number of standards initiatives which have a bearing on the use museums make of information technology. Overall procedures for collections management are set out in the guidelines for the MGC registration scheme (Museums and Galleries Commission nd), and in guidelines for the care of particular collections (Museums and Galleries Commission 1992a, 1992b). In parallel to these initiatives the MDA has continued to develop its recording media and documentation standards (Holm 1991), and has published a revised version of the Data Standard (Museum Documentation Association 1991), which takes account of contemporary data modelling techniques. Initiatives in both procedures and documentation have been brought together with the publication of *Spectrum*, a comprehensive guide to museum documentation standards (Grant 1994). In the United States the CIMI (Computer Interchange of Museum Information), has also been investigating the requirements for museum data (Bearman 1990; Bearman & Perkins 1993).

1.5 Archaeology

As would be expected, much of the work in archaeological information systems has been directed towards the design of systems for excavation records. Papers by Chapman (1984), Booth (1984a), Cogbill (1985), Stead (1987), and Huggett (1989) outline possible data structures. Ten years of work in this field by the Central Excavation Unit of the Department of the Environment are reviewed in the volume on archaeological computing edited by Cooper and Richards (Hinchliffe & Jefferies 1985). The volume by Ross, Moffett and Henderson (1991) provides a useful overview. Powlesland (1991) describes the rationale behind the development of the Heslerton recording system, and its translation into a computerised database. Post-excavation practice is surveyed by Richards (1991), and Williams (1991) describes the systems in use by the Department of Urban Archaeology of the Museum of London. Archive requirements are described by Schofield and Tyers (1985). Specific areas of interest which have been described include stratigraphic sorting (Wilcock 1982; Haigh 1985; Ryan 1988; Desachy and Djindjian 1990; Huggett and Cooper 1990; Boast and Chapman 1990; Herzog and Scollar 1990), and the integration of graphics with the field records (Flude *et al.* 1982; Alvey & Moffett 1986; Huggett 1989). Apart from the paper by Chapman (1984) there has been little discussion of the process of database design, although this is remedied to a degree by Ross (1991). However, several papers address the issues concerning the underlying database technology for archaeological records, including those by Grimley and Haigh (1982), Booth (1983a), Stallard (*et al.* 1984), Moffett (1984a, 1985), Ryan (1991), and Cheetham and Haigh (1991). The overall impression is of a number of independent developments, which often take account of work by others, but are closely linked to local requirements. There are no moves towards the adoption of a national system for the United Kingdom.

Developments in sites and monuments records, and the various records kept by the national heritage bodies are well documented, including publications by Moffett (1984b), Evans (1984), Leech (1986), Cheetham (1985), and Grant (1985). The 1988, 1989 and 1990 volumes of CAA proceedings each contain a group of papers on this theme (Rahtz 1988; Rahtz & Richards 1989; Lockyear & Rahtz 1990), and there are further papers by Lang and Stead (1992), and Robinson (1993). The volume from the Danish National Museum describes a range of initiatives (Larsen 1992), with the paper by Andresen and Madsen (1992) looking at the implications of the relational approach. Overall there is a pattern of consistency at the county level, encouraged by the national agencies, and coordinated by bodies such as the Association of County Archaeological Officers (ACAO). There is also increasing co-operation between the national agencies.

From 1986 geographical information systems (GIS) have become (as one would expect) of significant interest to archaeologists, and have been used directly linked to local and national sites and monuments records, and as research tools. They are discussed by Harris (1986, 1988), Clubb (1988), Wansleeben (1988), Lock and Harris (1990), Kvamme (1992), Castleford (1992), Ruggles (1992), Kvamme (1993), Middleton and Winstanley (1993), Chartrand *et al.* (1993), and Lang (1993).

Whilst the paper by Stewart (1984) discusses the overall role of museums, there has been little discussion of the relationship between archaeological fieldwork and museum collections. Developments sponsored by the MDA have been reviewed by Stewart (1982a; 1982b), and Light 1984. The paper by Keene and Orton (1992) describes an approach to assessing the condition of objects in a museums collections.

The application of expert systems to archaeology first appears in the record in 1985 when Wilcock assessed their potential. Subsequent contributions include Baker (1988), Doran (1988), Stutt (1989), Vitali and Lagrange (1989), Lock (1989), and Vitali (1991). These authors seemed to be inconclusive about the overall value of this approach, and interest seems to have subsequently subsided, for the moment at least.

Word processing, the use of CD-ROM and other forms of electronic publishing have been recurrent themes, including papers by Rahtz (1986), Wake (1986), Wilcock and Spicer (1986), Girdwood (1988), Martlew (1988a), and Jacobs and Klefeld (1990). Education as a theme has been amplified in papers by Rahtz (1988), O'Flaherty (1988), Martlew (1988b), Ruggles (1988), Biek (1988), Orton and Grace (1989), Wheatley (1981), and Ruggles *et al.* (1991). These technologies are also very much to the fore in the volume edited by Martlew (1984), including papers by Flude, Oppenheim, Sutton, Powell, Clark and Hassall. Virtual reality is likely to become a powerful technology for visualisation and communication (Reilly 1991). The potential of SGML (Standard Graphical Mark-up Language) as a means of tagging archaeological data for publication was first recognised by Rahtz (1986), subsequently these ideas have been developed by Smith (1992); with the adoption of SGML as a means of formatting data for Internet access this is likely to be an important tool. For these authors the potential of information technology in archaeology is as much in the dissemination of knowledge as in its recording and analysis.

The early 1980's saw a number of papers examining the strategic approach and proper use of computers in archaeology, including Flude (1983), Copeland (1983), Whinney (1984), McVicar (1985), McVicar and Stoddart (1986), Richards (1985), and Cooper (in Cooper & Richards 1985). Richards reviews the case for standardisation in the same volume, and Reilly looks at computers in field archaeology as agents of change. Further aspects are reviewed by Clubb (1989, 1991), and the development of an IS strategy is described by Booth (in press). The majority of the above themes were further developed in the CAA conferences in 1993 (Wilcock & Lockyear 1995) and 1994 (this volume).

Much of the impetus towards more rigorous field techniques and prompt publication has come from the Department of the Environment and latterly English Heritage. Building on from the Frere and Cunliffe reports (Ancient Monuments Board 1975, Council for British Archaeology and Department of the Environment 1983) there have been the two papers on the management of archaeological projects (English Heritage 1989, 1991a), the *Model Brief for Archaeological Evaluation* (Perring 1992), and three archaeological strategy papers (English Heritage 1990, 1991b, 1992), with a further document on rescue archaeology funding (English Heritage 1991c). The Central Excavation Unit (now Central Archaeological Services) has developed a manual covering procedures, recording, processing and publication (English Heritage 1985). A document setting the overall policies for archaeology and development is the *Planning Policy Guideline (PPG) 16* from the Department of the Environment (1990). The case for maritime archaeology to be given similar protection and resources that on land is outlined in a publication from the Joint Nautical Archaeology Policy Committee (1989). It is noteworthy however that apart from the Central Excavation Unit's manual, the English Heritage publications do not give specific instructions on recording for excavation and survey, and that whilst much thought is given to archive generation and storage, there is little attention given to dissemination apart from conventional publication.

In contrast there is substantial guidance on the form of sites and monuments and national records, starting with the issue of a form for recording monuments together with accompanying guidance (Form 107 and Advisory Note 32) by the Inspectorate of Ancient Monuments of the Department of the Environment (1981). The status of sites and monuments records, including some observations on record keeping and data processing were surveyed by the Department of the Environment in the publication *England's Archaeological Resource* (Inspectorate of Ancient Monuments 1984). The Association of County Archaeological Officers has produced several publications in this area, including *County Archaeological Records - Progress and Potential* (1985), *SMR's Some Current Issues* (1990), and *Policies for Access and Charging* (1991). As well as general guidelines there are several initiatives by the national bodies aimed at defining record types and terminology control (Royal Commission on the Historical Monuments of England 1986, 1987, 1992, 1993; Royal Commission on the Historical Monuments of England and English Heritage 1989). Together these provide comprehensive (and developing) standards for both local and national records.

1.6 Conclusion

This paper has attempted to show the potential that exists for the application of information technology to archaeology, and to describe developments in libraries and museums which are of relevance. There have already been a wide range of innovative uses of computing in archaeology, and there is no doubt that there are many exciting opportunities ahead. What is striking however is that archaeological fieldworkers who have the responsibility to recover, analyse and disseminate the results of their work, are for the most part not taking advantage of this technology, preferring instead to publish in the conventional manner. It falls to those record centres, museums and libraries that eventually receive archaeological data to make use of these new methods. In past generations archaeologists such as Wheeler sought contact with the public via the media of the day, and made great use of the press, radio and television to increase awareness of archaeology in the population at large. Todays archaeologists use computers for excavation recording, wordprocesing and a range of supportive tasks, but do not appear to be taking advantage of the broadcast potential which has been enabled by the 'Information Age'.

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