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Integrating spatial information in computerised Sites and Monuments Records: meeting archaeological requirements in the 1990s

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25.1 Introduction

Most county Sites and Monuments Records (SMRs) are now computerised to a greater or lesser extent. The value of these SMRs as repositories of the national archaeological record is considerable and they provide a rich resource for any analysis of the cultural landscape. Many SMRs are now reaching the end of the initial data collection and early computerisation phase. In this paper we review the current nature and status of SMRs and consider the implications for users, actual and potential, which have arisen from the present structure of SMR database design. In addition we discuss the emergence of new technology, Geographic Information Systems (GIS), which is now sufficiently developed to be particularly suited to possible further phases of SMR development. This technology provides a fully integrated spatial database management and analysis environment which would enable SMRs to go beyond the present limiting inventorying stage and provide a highly sophisticated information system. Such a system would be capable of greatly improved functionality, have advanced analysis capability, and be able to develop decision support roles in the management of the cultural environment. These technological advances necessitate the inclusion of the full archaeological record, including its spatial component, within the database environment.

The underlying basis of SMR computerisation was formulated under the financial and technological exigencies of the late 1970s and early 1980s. The present structure of computerised SMRs must be seen in the context of these origins. These factors have resulted in the construction of databases which closely mirror the structure of earlier manual card index systems. Thus the database can be searched for archaeological sites and artefacts according to a combination of single or multiple attributes based on boolean logic and standard database interrogative procedures. One major difficulty which has arisen from the general adoption of the standardised database structure mainly promulgated by English Heritage, however, has been the problem of how to handle the locational and geographical information associated with the archaeological record. While all would accept that without knowing where an archaeological site or artefact exists on the ground the value of the information is greatly diminished, in most SMRs the spatial description of the phenomena has been reduced to either a single Ordnance Survey point coordinate or to a nominal representation such as the parish administrative area. In many instances of course the inability to locate a find or site accurately on the ground invalidates the allocation of precise coordinates. No amount of sophistication in information retrieval system design will easily overcome the problems associated with the lack of information precision, though research within the field of GIS concerned with 'fuzzy space' may provide one very profitable avenue of enquiry. In nearly all SMRs the inability to incorporate the full spatial description of an archaeological record within the computerised database has resulted in the information having to be stored by hand on small scale Ordnance Survey topographic map sheets.

In this paper our concern is focused primarily upon the handling of the full archaeological record within the computerised SMR. To a considerable extent the way in which the spatial description of an archaeological record is currently handled greatly constrains the effectiveness and utility of the SMR to service the needs of users. To this end three aspects of the handling of archaeological information within current computerised SMRs are considered in the light of the current inability of SMRs to maximise their full potential as they are presently structured; in the light of professional and societal trends toward more sophisticated uses of computerised information systems; in the light of current developments in Geographic Information Systems; and in the light of recent government enquiries and reports into the handling of spatial information and the role of GIS technology in many areas of UK society.

The first concern arising from the structure of current SMR databases is that a vital component of the archaeological record, its spatial description, is reduced to a geometric form that in many instances clearly does not reflect reality. Thus linear features, such as embankments or ditches, and zonal areas, such as field systems, are simplistically recorded in the computerised database by the allocation of a single coordinate or a parish unit. It is usual for the coordinate to reflect the centroid of a structure. Some SMRs have attempted to describe the shape of such features with a series of grid references, using three for a linear feature for example. While this obviously contains added information it remains incapable of serious analysis. The implications of this, and other, database restrictions are discussed later. The second concern is that current SMR systems are unable to record the topological relationships which exist between archaeological, natural and human environmental phenomena. This rather technical aspect is also discussed later in the paper but the outcome of this omission is critical because it precludes any form of spatially oriented enquiry or spatial analysis being undertaken on the archaeological information within the database, other than that at a very elementary and crude level. This is especially relevant to the SMR user community for even basic requests for information concerning what archaeological sites exist within a certain distance of a proposed development, or seeking the relationships which might exist between various archaeological sites, or the extent of linear or multiple relationships existing between archaeological and environmental phenomena, cannot be pursued without some basis of topological relationship encoded within the database. The third major concern arises from this inability to store anything but a crude locational description of an archaeological record within the database. The result of this has been that the full geographical location, spatial extent and implied topological relationship of an archaeological record is stored separately, outside of the computer database, on Ordnance Survey paper maps. This 'stop-gap' procedure effectively divorces the important spatial component of the archaeological record from the computerised record; a procedure which runs counter to all professional developments in efficient database design and management. This not only precludes full blown spatial queries from being entertained but prevents the adoption of digital mapping procedures or even the use of digital topographic maps from the Ordnance Survey.

We suggest that the current inability of computerised SMRs to incorporate the full archaeological record and topological relationships within an integrated information system environment prevents the full potential of the SMR resource from being exploited. Our concern in this paper is that having reached this stage of development, the computerised SMRs are in danger of becoming fossilised and outmoded partial repositories of the archaeological record; archaeological gazetteers rather than the sophisticated information systems of which they are capable. To this end our focus is to review the present functional capability of SMRs and identify important future directions for system development which would enable SMRs to more fully meet the requirements of archaeologists and society well into the next millennium.

25.2 The development and functional capabilities of SMRs

25.2.1 SMR origins and early computerisation

The origin of SMRs lies in the strong British tradition of field work and site surveying going back to the beginning of this century (see Burrow 1985 for a detailed history). The appointment of O. G. S. Crawford as the first Ordnance Survey Archaeology Officer inaugurated a systematic approach to archaeological mapping and recording. Indeed, Ordnance Survey record cards have formed the backbone of most SMRs. The findings of the Walsh Committee (Walsh 1969), set up to look into the protection of field monuments, recommended that every County Planning Authority should hold a record of all known field monuments and have suitable archaeological expertise on their staff. In view of the threatened, and indeed actual, destruction of the archaeological resource due to rapid urban development, the government of the day reacted favourably to these recommendations. The result is that nearly the whole of the UK is now covered by SMRs. Importantly, emphasis is placed as much on detailed local archaeological information as on sites of national interest. The county-based SMRs are thus the most comprehensive and frequently updated source of archaeological information available in the UK (Holman 1985, Chadburn 1989) and provide a unique potential for regional spatial research in archaeology as well as cultural resource management. Every county in England, Wales, Northern Ireland and most of Scotland now has SMR cover, together with one or more professional archaeologist(s) specifically dedicated to the management of that record. All types of information are entered into the record although their main importance lies in the inventorying of archaeological sites. Despite the potential of this resource for academic research at all levels, SMRs are heavily focused on servicing cultural resource management activities within regional and local planning. Given the origins of SMRs and the location of many SMRs within County Council Planning Departments (Chadburn 1989) this bias in application is not surprising. However, we shall argue that this apparent schism between an invaluable archaeological resource and a potential major academic user group is partly due to the unwieldy structure of SMRs and reflects the failure of SMRs to fully integrate spatial information within the computerised archaeological database. Furthermore, we also argue that the spatial shortcomings of existing SMRs also severely limits their ability to perform even their primary tasks of cultural resource management.

The first SMRs of the late 1960s and early 1970s were based on manual card index systems with many adopting the Optical Co-Incidence punch card system (Benson 1974). Although the potential of computer-based SMRs was recognised in the late 1960s it was not until 1974 that the first application emerged (Benson 1985). Many SMR workers were slow to appreciate the advantages of computerised records. As late as 1978 the Association of County Archaeological Officers in their Guide to the Establishment of Sites and Monuments Records had to incorporate the Optical Coincidence card system as an option to the mainstream computerisation of the Record 'in order to satisfy those members who were perfectly happy to continue with a manual system. . . and who were unwilling or unable to experiment or invest in the more effective technology then available' (Benson 1985, p. 33). The last decade has seen the slow and somewhat painful adoption of computers by all SMRs with much discussion centred around the standardisation of records and terminology (Chadburn 1988). A recent survey (Chadburn 1989) has shown that the 46 SMRs in England display a wide range of hardware and software types with 33 being microcomputer based while the rest employ either minicomputers or mainframe systems. It is perhaps surprising that in the late 1980s 'a few SMRs still rely heavily on Optical Co-Incidence Cards for retrieval, and. . . can only undertake limited searches of their records' (Chadburn 1989, p. 22).

It is important to acknowledge the influential role played by English Heritage in the computerisation process of SMRs. This influence has taken the form of financial assistance, software development and associated advice. In the year 1987/88, for example, of the £3.5 million distributed through English Heritage 10% went to SMR work (English Heritage 1987). This financial and computing support is reflected in the number of SMRs that use SAMSON; software written by English Heritage and based on the database package Superfile. Of the 33 microcomputer based SMRs, 25 use SAMSON (Chadburn 1989, Table 3.3) despite it being based on a flat file database system lacking much of the sophistication and power of modern database packages. In return for this support English Heritage has been able to call upon the computerised SMR databases in the performance of its statutory duties. One such obligation is to keep a schedule of monuments of national importance which are protected under the 1979 Act. This schedule is currently being enhanced by the recently initiated Monuments Protection Programme (MPP) which is also going to be based on the interrogation of SMRs.

25.2.2 Spatial limitations of SMRs

While English Heritage have supplied considerable aid and advice to SMRs concerning computerisation of the register, this has been aimed almost exclusively at establishing a standardised database structure closely replicating the structure of the earlier card index system. Because of the difficulties of defining spatial objects and spatial relationships within a computing environment this database design precluded the inclusion of any but a crude locational component within the database. The result is that todays computerised SMRs perform the same sort of analysis as the earlier manual systems, albeit much more quickly and with greater flexibility. To reach this national situation within two decades is a significant achievement which should not go unsung for it has provided an important early base for 'informed decisions to be made about our cultural heritage, and [provide] a tool for a range of activities such as education, research and planning' (Chadburn 1989, p. 13). We suggest, however, that the development of SMRs now stands at a critical crossroad in its development. In essence we see the paths bifurcating between the route of continued development of the system along the existing database road, flat file or relational, or of opting toward the potential offered by the new technology of GIS. The choice confronting the SMR community centres largely on the perception of that group of the role and functionality of SMRs in the 1990s and, importantly, beyond. To a large extent the choice of direction is intricately tied to the apparently superficial consideration of whether, and how, to integrate the full archaeological record, including its spatial and topological component, within a computerised database environment. This aspect lies at the very core of our questioning of current SMR database design because of the implications that arise concerning system functionality, the role of SMRs, and the nature of user requirements.

At the moment the computerised SMR is built upon a standard database structure of records and fields which translate to a series of items (in this case usually archaeological sites) each with a list of descriptive attributes. This structure allows the usual kinds of SMR analysis such as the generation of catalogues by site type, parish, period or any other suitable field. A considerable amount of time and effort has been expended in standardising the fields within SMRs. Chadburn (1989, p. 14) has identified a 'record content standard', a series of data categories which most SMRs include in every record. Booth (1988) has suggested a standard for data transfer of site specific data intended for use between SMRs and other heritage databases, specifically the HBMC SAM Record and the RCHME NAR. Within all of these the spatial component of the record is treated as one or more fields; the two most important being the nominally measured 'parish' (it is either in, or not in, a parish), and specific point data in the form of a National Grid Reference. The present situation has evolved over the past two decades from *ad hoc* developments with little standardisation in hardware, software or content. However, one theme common to all SMRs has been their inability to satisfactorily integrate the full locational component of an archaeological record within the computerised archaeological database. Operating parallel to the computerised database, the SMRs have a series of 1:10560 scale (or metric equivalent) Ordnance Survey paper maps onto which each computer database entry is plotted by hand and referenced by a unique Primary Reference Number (PRN). These base maps can vary considerably in their date of publication and thus the completeness of the topographic information which they possess. To update a series of these maps by hand onto current OS maps would be a very time consuming process. Occasionally these maps will be associated with various overlays, older maps of interest, or coverages of more sensitive areas at different scales. The spatial information associated with an archaeological record is thus split between two different storage media and, not uncommonly, different physical locations within the same building. This rather inflexible and quixotic situation greatly restricts the range of questions that can be asked of the data and the quality and nature of the response from an SMR. Archaeological enquiries with an emphasis upon location must be phrased in terms of either the fields within the database record structure (usually related to the parish) for computer-based output, or map sheet number for manual cartographic output. Catalogues by parish, and crude database interrogation by grid reference will satisfy some spatial queries currently put to SMRs but a fundamental component of the archaeological record is actually stored off-line. This not only greatly restricts the range of queries that can be directed at the database but runs counter to all developments in database management systems. The result is that the SMRs represent only partially computerised systems of the archaeological record. The SMR database field specified for the locational information pertaining to an archaeological record at the moment simply acts as a pointer to the main spatial information repositories which are the maps.

25.3 Handling spatial archaeological information within a computing environment: the need for GIS

Many of the problems encountered by archaeologists in the handling of spatial information within a computing environment as outlined above have been known to geographers for some time. By definition the focus of the geographer's interest is the spatial component. The handling of geographic information is fundamental to good management, planning, and decision-making within the natural and human environments. As the House of Commons Report into the Handling of Spatial Information comments, 'Most human activity depends on geographic information: on knowing where things are and understanding how they relate to each other' (DoE 1987, p. 7) In archaeology the geography of sites and artefacts and the relationships between them is vital in explaining and understanding past societies. Considerable research has been undertaken, primarily by geographers, to develop principles whereby geographical information could be stored, manipulated and integrated within a computing environment. It is contended here that these technological developments in spatial data handling and analysis have important implications for archaeology and especially SMRs.

It is not the place in this paper to detail the nature of GIS. This has been undertaken with respect to archaeological applications in previous papers (Harris 1986, Harris 1988, Wansleeben 1988, Kvamme & Kohler 1988, Kvamme 1989, Allen *et al* 1990). A number of standard texts also exist in the GIS literature (Burrough 1986, Star & Estes 1990, Tomlin 1990). Suffice to say at this point that the traditional manual method of integrating spatial information has involved overlaying maps physically one on another and tracing the areas of intersection or union (McHarg 1969). The development of GIS has enabled the basic spatial primitives of point specific data, linear features and polygonal areas, as well as pixel based information, to be integrated and analyzed within a computing environment. What this involves is effectively the storage of phenomena as a series of layers of information, or coverages, within a database whereby each layer would represent a distribution traditionally represented in the form of a map (see Harris 1986). In this database the topological relationships which exist between the spatial entities are retained and are stored as part of the relational database. Thereafter requests for information concerning the location of archaeological sites or artefacts or their proximity one to another or to other features can be undertaken. Sophisticated spatial data handling or querying may be undertaken on the system. Thus requests for information concerning what sites existed at particular locations or specified areas may be entertained. Because any part of the database may be linked spatially with any other part map coverages may be overlaid and combined to produce new composite coverages which in turn could be stored separately within the database. Selected areas generated around designated features can be created by 'buffering' and used to extract portions of the database as required. By this method zones of a specified size or extent can be generated around a geographic feature or point, line or area and the buffered zone then overlaid on top of other map coverages to select and analyze phenomena falling within the designated area. Thus generating a corridor either side of a proposed road development and overlaying this buffered zone across a sequence of archaeological, or indeed ecological and socio-economic coverages, would enable the impact of such a development to be determined and evaluated against other route proposals. The outcome of this type of spatial query ability is that an archaeological GIS database would be capable of not only storing and retrieving the full geographical description of archaeological phenomena but of integrating, analyzing and subsequently digitally plotting archaeological phenomena and environmental variables held within the system. Importantly, the ability of the database to entertain full blown spatial queries would greatly improve the effectiveness of SMRs in their task of aiding planning decisions. Thus questions to an SMR from a planner are concerned less with the specifics of the archaeological record than with the overall significance of an impact on the cultural resource arising from a proposed development. Similarly an archaeologist could investigate any number of relationships existing between archaeological phenomena by period or specific site type with environmental phenomena such as aspect or slope or soil type.

This latter point opens up the discussion somewhat to consider the potential role of a comprehensive SMR information system possessing the full archaeological record and GIS capability for a range of applications ranging from cultural resource management to regional archaeological analysis. In the same way that the full spatial description of an archaeological site could be stored within a computerised GIS database, thereby enabling spatial linkages within the database to be explored, so other map coverages representing a variety of human and natural environmental phenomena, administrative and planning designations, topographic and infrastructural information may similarly be entered into the GIS database and integrated with the archaeological coverages. An SMR set up in this fashion would have almost limitless potential for managing the cultural resource and undertaking regional archaeological analysis. At this point the difference in system capability between the present SMR and a GIS based SMR in terms of functionality and flexibility in performing a range of applications is vast: the distinction between an archaeological information system capable of meeting the needs of society in the 21st century and that of a system struggling to inventory the full archaeological record. Given the increasing corporate nature of information in society, particularly in a planning environment where several departments share and make demands upon the same information sources, it is no surprise to learn that a number of government agencies and county planning authorities are currently considering or building a regional GIS database. The utility companies are already well advanced with such systems. A large number of these activities rely upon having a spatial querying capability because it is the distribution and variation of objects across space which forms the basis for analysis and decision making. The early computerisation of regional SMRs would provide a core around which these geographical information systems could be constructed.

A clear distinction should be drawn at this stage between digital mapping or CADCAM systems and GIS (Cowan 1987, Dangermond 1986). We cannot stress this enough as our experiences within the SMR community show a widespread misunderstanding that database plus digital mapping equals GIS. This is not true. GIS do possess considerable mapping capabilities, for maps are the most effective medium for storing and interpreting complex spatial information. But while digital mapping systems have been in existence for many years these systems are without the capability of integrating or analyzing the full spatial range of spatial information. Thus while thematic information may be mapped by these systems, any integration of data must be based upon a common spatial unit or zone, such as the parish or county. Any variation from this geographical unit, for example to overlay and combine differing spatial units such as soil type zones with later prehistoric field systems could not be accommodated. Similarly, while other features could be digitally encoded and drawn onto the maps, the systems possess no functional ability to combine, analyze or interrogate the spatial or topological relationships which exist between the features. GIS are an analytical engine with digital mapping being just one of several forms of output.

GIS then are specialist computer information systems which enable spatial and thematic information to be digitally encoded, stored, manipulated, retrieved, analyzed and output in a variety of forms. Handling geographic information within a computerised system has presented a number of problems though recent developments in the storage capacity and processing speed of computers, in tandem with significantly reduced hardware costs have overcome some of these difficulties. These improvements have stimulated the development and use of GIS in a wide range of application areas. Furthermore, the ease of use and the reduced cost of 'off the shelf' specialist GIS software has brought such technology within the purview of many non-specialist users. Already considerable amounts of geographical information, such as archaeological data, satellite imagery, Ordnance Survey topographic maps, and population census data exist in digital form. Together these developments have facilitated the development and application of GIS as a tool for undertaking advanced forms of computerised spatial data handling and analysis.

25.4 User requirements

Some of the advantages to the potential user arising from the adoption of a GIS oriented approach to SMR database design have already been mentioned. It is noticeable that while much has been written about the development, structure and organisation of SMRs, the specific needs and information product requirements of the user community have not been as fully addressed. Caution must be exercised when assessing current SMR user requirements because long-standing users of SMR data are well aware of the limitations of SMRs. The nature of current user queries are thus more indicative of the known capabilities and limitations of the system than of their own information needs. To illustrate the shortcomings of the existing database structures and the potential of a fully integrated system we identify two major types of SMR user. The first group comprise *ad hoc* researchers, whether university, museum or unit based, who have site, period and/or locational specific archaeological interests and information requirements. The second user type involves those in the planning environment with much less specific archaeological interests but with as great a need to be able to manage and conserve the cultural resource and assess the possible impacts arising from development permits being granted. It is the latter group who dominate the SMRs at the moment. In both cases it is difficult to envisage a scenario where users would not be interested in the locational component of the information requested. It seems more than likely that if these needs could be assessed, spatial functionality would be high on their list.

Personal experience of a research oriented request for information from an SMR for information concerning all prehistoric sites in an area of five by ten kilometres, for example, typically generated a five centimetre thick computer printout and two large photocopies of maps (each covering a five kilometre square) covered in hand-drawn black markings and corresponding PRNs. The user in this case is left to extract the required information from the data contained in the printout and maps. In essence this represents the inventory nature of the SMR rather than that of an information system capability to which we allude. GIS possess the ability to hold many map extents or partitions within its database. Most GIS have edge matching capabilities which enable them to generate apparently seamless map extents. Thus it is possible to generate a window over a particular geographical area and extract information according to the specific areal requirements of the user. Similarly any combination of information within the database could be extracted for these specified areas. It is also virtually impossible at the moment to produce extract maps from the SMRs. The example request for prehistoric sites is likely to produce a map showing blanket coverage of the total SMR for the area in question leaving it up to the researcher to extract the relevant site locations. If the content of the database extended to include altitudinal information or soil type information then recall of archaeological information could as easily be based upon specified combinations of zones generated from these coverages as from the standard tile or OS map sheet. How more apposite it would be to have the capability to search a database using not just thematic criteria but spatial criteria. Thus if planning areas or soil type coverages existed within a system then requests for information combining specified sites falling within a planning zone or a set distance from deposits of clay with flint, or within a designated planning area, or within a certain distance of contemporary urban areas, could be a commonplace occurrence. This scenario does imply the availability of map coverages within the system other than just that of archaeological distributions. Given the high initial cost of data input this is no small concern. However, the corporate nature of much of this information, the need to service many users, and the existing and future availability of vast quantities of geographic information in digital form such as satellite imagery, OS topographic maps, utility company maps, and census information, suggest that this is an achievable scenario now and not just far into the future. Evidence of such applications in North America demonstrably support such a claim. Needless to say computer listings could be generated and digital map output generated automatically by the GIS. To this extent maps could be output without recourse to extensive computer printouts or the photocopying of hand drawn maps. Output could also be sent to a user in digital form via electronic mail or disk storage and provide the basis for subsequent computer analysis. Such a system would be eminently suitable to meet *ad hoc* archaeological enquiries.

Even obtaining copies of the maps currently linked to the SMRs introduce other problems related to the handling of spatial information in the archaeological record. Archaeological sites are currently spatially referenced on these maps by a symbol, the size and extent of which need bear no relationship to the actual size of the site on the ground. A small barrow, for instance, or even a single artefact are represented by a symbol which is probably hundreds of metres in size if taken to scale. It is the same in reverse for large sites; even if they are shown to size on the map, in the database they are recorded by a single point grid reference. A well preserved late prehistoric field system, for example, which may be many hectares in extent, is carefully drawn onto the OS base maps. In the database, however, it is represented by a single grid coordinate with no indication of shape. The size of a site may be recorded as a separate data category. Even greater problems arise when trying to record linear features because a grid reference of the centroid is completely inappropriate. As well as this inability to describe the basic spatial size and shape of data, current computerised SMRs are also incapable of analyzing spatial relationships. If a later prehistoric linear ditch system connected several field systems and possible contemporary settlements were within 2km of them, these spatial relationships could only be recorded digitally using crude nominal coding within existing computerised SMRs.

Not only are the computerised databases unable to provide archaeological information in a form which satisfies many research enquiries but in their present computerised form they also fall short of satisfying the requirements of their major user group. Because of the ever present pressure on the historic environment in the UK from urban and rural development, the main application of SMRs has been geared firmly toward servicing planners and the extensive planning system in the UK. Most enquiries originating from planning authorities are concerned less with the archaeological content of the record *per se* and more with assessing the significance and possible impact on the cultural resource arising from the granting of planning permission to a developer to build at a given location. Many planning enquiries therefore are spatially oriented and geared toward knowing about what exists, or often what might exist, at a given location or the area immediately adjacent to it. In this case the computerised system is abandoned at the first hurdle to play a secondary role to that of the primary visual inspection of the hand-drawn maps. Through a laborious process of cross referencing the maps with the database it is eventually possible to estimate the total impact of any development and to present that impact in a graphical format. What is needed ideally is the ability to define a spatial unit of any size and shape, produce a map of that area showing spatial archaeological data together with any other spatial data of interest and automatically link sites within that area to the attribute database. Linked to this should be the possibility of modelling the computerised database or establishing a predictive capability based upon multivariate relationships for example, which is not possible at the moment because of the lack of the full archaeological record in the database.

25.5 SMRs in the context of broader developments in information handling

Besides the problems associated with analysis detailed above, there are major problems involved in the management and updating of data kept in manual map form. Maps are notoriously difficult to update and tend to fossilise information. While this does not necessarily apply to the archaeological information on the SMR maps, which can be added or altered manually either directly onto the base maps or using overlays, it does apply to the underlying OS topographic base maps which are often years out of date; a last major revision in the 1950s is not unusual. When a new version of a map is released by the OS a situation could arise where the whole SMR would have to be copied by hand from the old to the new maps if the latest topographic information were to be utilised. Further, the digital encoding of these maps is presently being undertaken by the OS to provide national topographic coverage. This digital resource will form a major topographic database for the UK which may be linked with other environmental databases. Without a full locational reference, however, the SMRs will only be able to tap a small part of the potential offered by the availability of this digital map information. The storage of map information in digital form would not only allow easier updating of both archaeological and background information it also reduces the dependency on the OS to produce updates. Local changes in data with a spatial component can be immediately incorporated into the database. Another aspect of SMRs which is severely limited at the moment is integration with other types of environmental data. Archaeology has been painfully slow to integrate with other areas of landscape conservation despite the fact that the archaeological record is a finite and rapidly disappearing resource. The greening of British politics over the last few years has included only a minimal archaeological input. A trend toward a coordinated and integrated approach to the many different strands of landscape conservation could be a major motivating factor for the adoption of GIS in archaeology on a large scale. Much of this integration would undoubtedly occur at the county level and the SMRs could be central to this process. This raises the interesting possibility of SMRs moving away from being independent, self contained units to being a part of a county wide 'corporate database' together with the associated questions of data access and data security.

Returning to the earlier example of a planning enquiry, it is important to know whether the proposed route for a new road impacts on *any* environmentally sensitive areas. The ability to define a linear corridor through the landscape and see whether it includes any SSSIs, nature reserves, historic buildings as well as archaeological sites is the level of integration which is now possible with GIS technology. It may be that many SMRs are introduced to this new technology on the coat-tails of county planning departments. GIS certainly offers the opportunity for archaeology to raise its public profile and integrate with not only other environmental databases but with conservation and resource management concerns as well. This potential has not gone unnoticed by some archaeologists working within planning departments where the establishment of GIS based 'Environmental Records' are being investigated. Certainly, GIS based SMRs enabling the integration of the spatial and thematic components of the archaeological record as well as other environmental data offer an attractive view of the future in which improved and more diverse uses of these archaeological databases are thereby encouraged. To capitalise fully on these new opportunities it is essential to be able to digitally record the extent, nature, and shape of each site. A basic premise in archaeology is that human activity involves the ordering and use of space and that such activities are likely to be represented by patterning within the archaeological record. As such, archaeological phenomena are underpinned by their unique position in space and time and by the latent relationships existing between them. The spatial component in archaeological analysis is thus particularly important and yet has been excluded from the SMR computing environment because of the difficulties previously associated with integrating archaeological information which differ in their basic spatial unit. The fundamental decision facing SMRs is whether or not the integration of point, line, polygon and pixel data within a computing environment is important. It seems clear from both user and data management points of view that a move in this direction is necessary if SMRs are to meet future demands.

GIS technology has been developing since the 1970s and several systems are now available which will handle the DBMS and the spatial/mapping requirements of SMRs. The cost of such systems are rapidly falling in real-terms. Technological limitations determined the structure of earlier SMR database design in the pursuit of a faster computerised version of the manual card index system but now developments are such that a reconsideration of where SMRs are going is necessary. Any system that claims to be computerised and yet excludes a major element of its primary data from the computing environment must be at an early stage of its developmental path. We accept that GIS may still be an unrealistic option given the resources, support and training available to many SMRs but it must be acknowledged that GIS technology is available, that GIS could make a substantial contribution to SMR development, and that they are going to become more extensively involved in all aspects of society and especially in urban and regional planning activities.

25.6 The Chorley Report, GIS and archaeology

Discussion of the application of GIS technology to SMRs cannot take place without placing it within the wider context of the diffusion of GIS technology through other sectors of society and archaeology in general. GIS are anticipated to have a major impact on the way in which geographic information is handled by society. The commercial importance of this technology has been recognised by the U. K. government. In 1987 the House of Commons Committee of Enquiry chaired by Lord Chorley published its report into the Handling of Geographic Information (DoE 1987). This enquiry, in turn, had arisen out of the 1983 House of Lords Select Committee report on Remote Sensing and Digital Mapping (H.M.S.O. 1983). These reports and subsequent Government responses (DTI 1984, DoE 1988) emphasise the government's concern to exploit the potential offered by these technological developments. These developments are not unique to the UK but are currently taking place in many countries and especially North America. The uptake of GIS in the UK to date has been limited. In archaeology it has been minimal (Harris & Lock 1990). Much of this response can be directly attributed to the widespread lack of awareness of GIS capability and of potential application areas. In raising this user awareness the Chorley Report has important implications for the wider GIS user community and not least for archaeologists. The 1987 Commission had no doubt about the importance of GIS and its anticipated impact on society. The development of GIS, the report claimed, was as significant to spatial analysis as,

> "the invention of the microscope and the telescope were to science, the computer to economics, and the printing press to information dissemination. It is the biggest step forward in the handling of geographic information since the invention of the map."
>
> DoE 1987, p. 8

The report highlighted a number of barriers which prevented the full benefits of GIS being obtained. The principal barrier was the lack of user awareness about the central importance of these systems and of their potential benefits (DoE 1987, p. 1). The Committee acknowledged that the falling costs of computer processing power and memory, as well as GIS software, would greatly facilitate the adoption rate of GIS.

The general lack of awareness by many in the UK of GIS technology which the Chorley Report highlighted is particularly germane to this discussion about the possible nature of future SMR developments. This is because of the long term nature of financial investments being made by sponsoring organisations. Investment decisions concerning SMRs undertaken now will largely determine the future shape and direction of SMR development. Given the scarcity of resources such decisions will have to be lived with for some time. For this reason alone awareness of GIS and its potential for SMR development should be recognised by the sponsors and the SMR user community. Decisions concerning the SMRs should at least be made in the full knowledge of these technological developments. Elsewhere we have reviewed a number of possible scenarios for the adoption of GIS within UK archaeology (Harris & Lock 1990). A number of issues were identified concerning raising the awareness of archaeologists to the potential of GIS, as well as about educating and training personnel in their use. What became clear from this analysis was the central role which SMRs could play in this diffusion process. As a result of the rich detailed archaeological record maintained by the SMRs and of the national coverage, any decision by SMRs to adopt, or not to adopt, GIS technology will have major implications for the widespread adoption of this technology by UK archaeologists. As the Chorley Report stressed "The full benefits of sharing geographic information and Geographic Information Systems cannot be realised unless all the potential sharers are aware of them". Thus while some sections of the archaeological community may adopt GIS relatively quickly, the main benefits of adopting this technology would remain limited because of the lack of awareness or rejection of GIS by others and because of the constraints to developing archaeological GIS databases independent of the SMRs. Rejection or prolonged resistance to GIS by the SMRs would certainly affect to a major degree the ability of archaeologists and other archaeological data users to tap the full potential of these rich regional databases, undertake full spatial analysis, or exchange archaeological information.

The decisions of government agencies such as RCHME and English Heritage could be expected to have an important rôle in this respect because these organisations have to date, and will have in the future, considerable influence over the purchase of SMR hardware and software and the direction of SMR database development. While both the RCHME and English Heritage have considered the Chorley Report and its recommendations in the light of their current working practices, neither organisation is formulating an official response for external publication. A note of optimism does exist from the knowledge that within the RCHME GIS is a 'live issue forming a part of the formulation of a new information strategy document' and may possibly comprise 'the core part of future retrieval systems' (Grant, pers. com.), especially when combined with the recent increase in RCHME funding which is partially earmarked for improving computer capacity, together with their new lead role for SMRs (RCHME 1990a, RCHME 1990b).

25.7 Conclusion

SMRs originated as map based systems as part of the OS service and in some respect we are advocating a return to that spatial emphasis. The emphasis of the computerisation of SMRs has been to split the full archaeological record and create databases which mirror the structure of the antecedent card index systems. The spatial element is relegated to a separate storage medium about which little in the published work on SMRs ever seems to be written. Of concern to us is what appears to be an unwritten belief that the two will remain separate. In this paper we have suggested that there is a need for a fundamental shift in archaeological computer database philosophy toward utilisation of the new potential offered by technological developments in GIS. To this end emphasis in database development should be toward the integration of the full archaeological record and of the topological relationships between them within the database.

To conclude we return to the Chorley Report and some illuminating evidence given to them by a company long involved in establishing GIS in North America:

> "In dealing with a relatively new technology such as GIS we have found over and over again in North America that the technical problems are minor in comparison with the human ones. The success or failure of a GIS effort has rarely depended on technical factors, and almost always on institutional or managerial ones"
>
> DoE 1987, p. 154

The Report goes on to note,

> "In short, we believe that the greatest obstacle to greater GIS use will continue to be the human problem of introducing a new technology which requires not only a new way of doing things, but whose main purpose is to permit the agency to do a host of things which it has not done before, and in many cases does not understand"
>
> DoE 1987, p. 158

In the context of GIS and the SMRs, and indeed archaeology in general in the UK at the moment, such comments are particularly apposite. The application of this new technology within SMRs would have a substantial impact, we hesitate to use the word revolution, not only in the ways in which archaeologists handle and use spatial information but in the ways in which archaeological information itself is used within other sectors of society such as planning and cultural resource management.

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