17 From model to machine: procurement and implementation of Geographical Information Systems for County Sites and Monuments Records

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17.1 INTRODUCTION

The importance of Sites and Monuments Records in Britain has been highlighted in several papers at CAA over the last six years. There have been critiques of the current de facto standard software in use (Iles & Trueman 1989), critiques of urban data standards (Lang 1989), discussion of the theoretical basis for SMR databases (Lang & Stead 1991), and examples of the potential of linking these to GIS (Gaffney & Stancic 1989, Kvamme 1989; Lock & Harris 1991). Nonetheless, the fact remains that the vast majority of SMRs in Great Britain are closely wedded to what can now be recognised as an antiquated and inappropriate data model and increasingly dated software.

17.1.1 The procurement process

In his very useful overview of the procurement process, Clubb (1991 a) discusses the strategy for and implementation of the procurement process for the Record of Scheduled Monuments between 1987 and 1989. His discussion is oriented towards procedures for medium to large Central Government systems. Most SMRs deal with much smaller systems, and smaller set–up costs, but over the five to ten years that SMR computerisation costs have been accumulating, all systems will have incurred costs in excess of £100,000 (including data entry and support). In larger and longer established systems, this figure will be considerably greater.

The objective of procurement is to obtain what is needed at the right time and for the best value for money throughout the life of a project. In the case of SMRs, assuming the basic organisational framework remains a constant, this life–cycle will run from inception to replacement by a more efficient and advanced system. Compared to the utility of the data, the utility of the computer environment selected may be very short — as little as three years for a personal computer system, and between five and seven for a medium to large system. In some cases, the speed of technological change can make systems seem dated as soon as they are put into full production.

17.1.2 Information technology and implementation

By contrast to the pace of technological development, the pace at which information technology is applied in many areas of local government may be fairly compared to a lethargic gastropod. Central government fairs only a little better, perhaps moving at the pace of a L'Escargot GTi. Such caution might lead one to assume that IT products in these generally conservative institutions will be tried, tested and robust. It is somewhat alarming then, to consider the number of overblown IT projects which have been abandoned after six or seven figure expenditure. The heritage bodies with which this paper is concerned are generally not IT consumers of this order of magnitude (with the exception of major Central Government initiatives). Nonetheless, the costs of implementing information technology are generally underestimated, and considerations for effective procurement and project management, particularly for Sites and Monuments Records, appear to be, in general, poorly understood.

In this paper, a review of selected aspects of the procurement and management of an IT project

for a local authority SMR system is offered, with particular reference to GIS. The paper will describe progress with the West Midlands Sites and Monuments Record, which has been considering its database requirements since 1988. The fact that, as one of the SMRs most interested in developing and using RDBMS and GIS technology, it has taken four years to acquire the hardware and software environment to implement these requirements is indicative of the speed at which it is possible to progress in such projects in local government.

Indeed, when this paper was originally envisaged, it was believed that system deployment would be at an advanced stage. Unfortunately, this expectation has not been fully realised, though we are now progressing steadily with the implementation. This paper briefly discusses the model adopted for the SMR, and the functionality of the RDBMS/GIS software selected to run this. The potential the system offers for fulfilling and extending the role of the SMR is very substantial, though it should be noted from the outset that the project, in its present form, could not have been conceived without the backing and resources of the West Midlands Joint Data Team, and the common requirement for the technology by the other planning and engineering functions within the Data Team.

17.2 THE CONTENT OF SMRS IN THE 1990S

17.2.1 The origins of SMRs
The history of SMRs in England has been well documented (see for example, Chadburn 1989; Lang 1991), but their future requirements have received less detailed attention. The databases have emerged from a tradition of recording field monuments, while the last decade has seen a major shift in the general perception of the archaeological heritage within the profession and hence the requirements for its recording. Not only are we becoming more interested in the recent past, we are refining the criteria through which we designate "importance". This, alongside the new planning environment for archaeology (eg DoE, 1990) make it more desirable than ever before that information technology supports and guides strategic and reactive planning, and attracts new constituencies of database users (a point as relevant to central government, as it is to SMRs).

In fulfilling the requirements of SMRs in the next decade, the depth and breadth of the database will need to be considerably revised. The following are the areas to which the West Midlands SMR has paid particular attention, though other

SMRs will wish to explore additional areas (for example, maritime databases).

17.2.2 Key areas for development
Six key areas for new database development, have been identified:

17.2.2.1 Structural remains
The last decade has seen a significant trend towards the archaeological recording and interpretation of standing structure, and building recording. Much of the debate has centred on the objectivity or subjectivity of the recorder (see for example, Bold 1990; Ferris 1991). Whichever standpoint is taken, the observations made will need to be distiled into a database, which, if it is to be particularly useful, will need to be both expansive and carefully structured. Recording may need to encompass architectural details, like structured fields — walls, roof, openings, rainwater goods, floors, ceilings, and so forth — as well as the interpretation of the building, in terms of history and functional contexts. These will be challenging areas, whether one subscribes to the interpretive or objective schools of recording, but the effort required in data gathering will need to be carefully balanced against the potential benefits of such a system.

17.2.2.2 Industrial Archaeology
Industrial archaeology could, at one time, be satisfactorily classed alongside such fascinating and purposeful hobbies as stamp collecting and train spotting. With the same fervour that the industrial barons applied to the "Industrial Revolution", the industrial archaeologists have collected and hoarded their data, developing considerable expertise in a locality or a particular industry, tempered by a peculiarly parochial outlook, and occasionally, a rather paranoid fear of missuse of "their" data.

There can be no doubt that industrial archaeology in Britain is important, but successful management can only be achieved through quantification and assessment of the resource, and the effective integration of local expertise into a wider perspective. It is only in the last decade that the subject is being developed beyond the resuscitation of steam engines, to the definition of significance criteria. In years to come, we may even be able to approach the kind of social archaeology of the industrial era which Hobbsbawm argued for over ten years ago (Hobbsbawm 1979)

17.2.2.3 Rural landscapes
While discrete sites have generally been susceptible to recording, in recent years greater interest

has been focussed on the potential of landscape archaeology. The inter–relationships of sites are often crucial to the understanding of past societies, and this interest should be reflected in the databases recording them. At a minimal level, the fact that a site forms part of a larger whole needs to be entered as an attribute for development control purposes (the concept of group value) — often rather crudely modelled by cross–referencing primary record numbers. The ability to interrogate and manipulate such relationships, particularly as a spatial view, would make these databases far more attractive to researchers. Many "landscapes" are only revealed as cropmarks, and progress nationally towards morphological schemes of classification and recording is being made (eg Edis *et al.* 1989).

17.2.2.4 Urban townscapes and sub–surface archaeology

The archaeological recording of towns is very weak in most SMRs, alongside other building records, or sub–surface deposits, recorded on computer (Lang 1989). GIS provides comprehensive spatial analytical tools for the management of urban records, but this must be allied to an appropriate base map scale.

One of the major deficiencies in local authority and central government databases is the recording of below ground archaeology in towns. This has been recognised and is beginning to be addressed through a recent English Heritage initiative, in conjunction with the Royal Commission on Historical Monuments to develop standards in the recording of Urban Archaeological Databases (English Heritage 1992).

17.2.2.5 Time–slicing procedures

At present, progress towards modelling temporality in databases has been limited, and it is doubtful whether any SMRs can reproduce even a simplified reversion of the database to a given moment in time. Ideally, the SMR would become a tool for assessing change over the medium to long term to the knowledge–base for archaeology, and alterations to the survival and condition of sites through time. This is particularly relevant to GIS structures (Castleford 1992).

17.2.2.6 Management Systems for SMRs

As the number and sophistication of archaeological interventions (including those to standing structures) increases, so the value of an information support system will develop. This may range from extending support for development control eg automation of checking on planning history of

a site, or adjacent developments to periodic maintenance scheduling, for example in controlling erosion on earthworks, provision of statistics to support budgetary control, and to the monitoring of officer time on particular projects, particularly relevant in the present climate of cost–centres and service level agreements.

17.3 PROCUREMENT OF THE SYSTEM

17.3.1 Summary

The following are the principal events over the past five years in the procurement of the West Midlands system, which may be compared to conventional stages in the procurement cycle given in squared brackets.

1988 — decision to migrate from Superfile following recognition of shortcomings with software; first consideration of "post AM107" database model; implementation envisaged as compiled dBase system on PC [analysis of current system, preliminary analysis of functionality required from system]

1989 — West Midlands SMR transferred to Joint Data Team; availability of additional facilities e.g. computer–based mapping; implications of database selection for corporate use within the Team [{Revisions of} functional specification; software environment; development of operational requirement]

1990 — compiled dBase systems rejected; consideration of more powerful PC relational databases; initial talks with Oracle and Ingres; database model refined; [selection of hardware/software environments]

1991 — evaluation of Oracle and Ingres completed; evaluation of GIS systems commenced; first 3 SUN Sparc stations purchased; agreement and tender to secure a further 4 Sparc stations; selection of Ingres [decisions on hardware platform and software suppliers; invitations to tender for extension to hardware]

1992 — purchase of further four SPARC stations; selection of Genamap GIS; training for Ingres/Genamap put in place [migration strategy from Superfile to Ingres/Genamap; system build commenced]

Beyond this, the RDBMS/GIS will be subject to testing and debugging at specified stages of implementation, periodic maintenance and further development since the functional requirement inevitably changes during the life of the system, and finally, decommission, and transfer of the data to a successor system at which time, the cycle is started once again.

It is interesting to compare this summary to a conventional procurement cycle. It is notable that the development has been strongly influenced by the constraints and opportunities arising during the procurement cycle; as with most other SMRs, the options within available budgets in 1988 were extremely limited. One of the advantages of having had a relatively long procurement cycle is the benefit of the significant technological improvements during this period, and the trend towards considerable reduction in hardware and software costs. However, the benefit has been reaped at the expense of a timetable which has sliped significantly, and a somewhat ad hoc style of implementing procurement phases as compared, for example, to CCTA guidelines — CCTA, 1989.

17.3.2 The data model

The basic data model used for the West Midlands SMR has been described in detail elsewhere (Lang & Stead 1991). This divides records into physical space and archaeological entities which relate to physical space on a recursive one to many basis.

A record will consist of four basic elements:

- A location — (where the site is).
- A site description — (what the site is).
- Management attributes of the site — (how the site is being looked after)
- Sources of information about the site — (who has provided the information).

The final element being worked towards is the inclusion of the time at which observations were made, but time–slicing or date stamping procedures provide one approach (for an extensive discussion on temporality, databases and GIS, see Castleford 1992).

The archaeological entities may be divided into six basic groups, each of which has particular attribute recording needs:

1) Standing structures
2) Sub–surface archaeological remains
3) Cropmarks
4) Earthworks
5) Findspots
6) Historical Ecology

17.3.3 Selection of the Database Software

Having defined the operational requirement of the system, an evaluation of possible database products was undertaken, examining the following "groups" of products, in varying degrees of detail:

17.3.3.1 dBase and compiled dBase systems

This option was initially attractive, in view of the common use of dBase and similar products such as Clipper and Foxbase amongst the archaeological community. Consultancy and support is readily available, and dBase skills are held by many users and potential future employees. The large volume of current users also provides security in future support and investment, borne out by Borland's policies since buying the product from Ashton–Tate.

17.3.3.2 Other PC databases — Paradox, Advanced Revelation

Various other PC databases were examined, including Borland's Paradox, and Advanced Revelation, used by the Biological Recording Centres (the ecological equivalents to SMRs). While these are worthy products in their own right, they lack (or lacked) support for UNIX, and their capabilities in respect of linkage to GIS systems was uncertain.

17.3.3.3 "Heavyweight" relational databases — Oracle, Ingres, Informix, and Sybase

The performance of the products of the mainstream relational database vendors provided the most satisfactory basis for a corporate database for the Team.

Oracle and Ingres were selected for detailed evaluation, examining the database server, application development tools and company profiles, including support, research and development, financial stability and the size and structure of the UK user base (Lang 1991).

17.3.4 Maps and character databases

For a number of years, the potential of GIS systems to transform archaeological sites and monuments records has been highlighted (eg Lock & Harris 1991). The proverb, presumably Chinese, which asserts that «one picture is worth a thousand words» has often been put forward as a justification of the virtues of the cartographic medium. In fact, the proverb disguises the essentially different nature of maps (pictures) and meaningful patterns of vocal sounds, and their corresponding written symbols — what we term "language". In a very general sense, mapping may be considered to be a language to the extent that it allows communication about the milieu among those who understand the rules and characteristics of mapping.

But when used more precisely, the term language refers to the exchange of thought amongst humans by means of a culture–specific set of

sounds and images, consisting of spoken and written letters, words, and a structural grammar. There is really no such general term for the analogues of these aspects in the communications of spatial knowledge in maps and mapping. In contrast to written language, the meaning of a map is contained in a figure, consisting of a complex array of potential sub–figures viewed in a non–linear unpredictable series of visual fixations.

A further distinction may be made. Whereas someone viewing a page in a foreign text which can be described but not comprehended would not be considered to be "reading" this, in the case of the map, there is a less comfortable distinction between the "map reader" able to visualise a series of red contours as a 3 dimensional landscape, and one who sees simply red–lines, (and the various gradations between these extremes).

This poses a considerable responsibility in the design of spatially oriented databases, where the information retrieved may not be primarily textual but a visual display resulting from an analytical procedure. Checking the validity of analyses, whether produced as tabular output or as a plotted map, may often rely entirely on a "visual" check, as to whether or not the output "looks right". A further point may be made — the cost of composing the "picture" may be a thousand times more expensive than the "words" in more familiar character databases.

17.3.5 Selection of the GIS software
The interest, nationally, in GIS would appear to be extensive. However, so far few organisations have been able to do more than pilot trials for a full system. In the longer term, access to GIS technology is likely to be governed by corporate policy within the counties and districts. Without support from central government institutions (which is unlikely to be forthcoming in the present financial climate), take up of GIS in local government will depend on its general use within the planning sphere.

In selecting a GIS, two possible approaches were open to the SMR. The first was to purchase an inexpensive standalone GIS, which would be used primarily by the SMR alone; the second, was to persuade other members of the Data Team that a GIS system would fulfil a corporate need, and in the long term would be paid for through savings on Mainframe usage, and the generally more efficient data handling capabilities this would provide.

17.3.5.1 Assessing the market
Of the GIS products at the lower end of the price scale, the Geographic Resources Analysis Support

System (GRASS) was seriously considered as a standalone GIS for the SMR. This is a raster–based GIS written in C, and running under UNIX. Its production background for the US Army Corps has ensured a high performance system (it was originally intended for land management around military installations), though it has subsequently become available as public domain software. It is unusually well documented and supported for public domain software, and the large user base has resulted in continued development. This has succesfully been used by several archaeological organisations eg the Arkansas Archaeological Survey.

However, after succeeding in demonstrating the relevance and potential for GIS to other areas of the Data Team's work, it was agreed that purchasing a more comprehensive corporate GIS was justifiable.

17.3.6 Criteria for selection
Although substantial GIS testing could not be incorporated into the procurement excercise for example, constructing an identical application in each software product, organisations selected were assessed against the following criteria. These are not, by any means intended as a comprehensive check list to assess GIS, but were particular areas relevant to the Data Team's needs, and are likely to be common to many organisations undertaking an assessment exercise.

17.3.6.1. Operating Systems
The SUN SPARCStation network selected as the Data Team's UNIX platform will be required to provide service for at least five years though already, this is receiving upgrades. It was therefore essential that the software selected should have a strong UNIX pedigree, and preferably, list SUN amongst its primary platforms for porting new releases of software.

17.3.6.2 Conformity to Open Systems
In view of the multiplicity of operating systems, and variants for example, over 40 flavours of UNIX, and the disadvantages of becoming locked into proprietary systems, a policy of conformity to recognised or de facto standards was considered important.

17.3.6.3 Simultaneous raster–vector handling
As with the English Heritage mapping system for the Record of Scheduled Ancient Monuments (Clubb 1988), a requirement for the simultaneous use of raster cell maps and vectorised information had been identified. An important considera-

tion in GIS selection is the provision of mapping at an appropriate scale. Since most SMRs currently operate a 1:10000 base map, this would seem to be the minimum scale which could be selected. After analysing various alternatives, 1:10000 dichotomous raster maps were selected as the main system "backcloth" to vectorial overlays organised into thematic layers depicting sites, topography, transportation routes, etc...

17.3.6.4 Connectivity to RDBMS
At the time of assessment, Ingres had already been selected as the Data Team's relational database. Although most GIS will communicate with an RDBMS via a SQL link, many products require the developer to build the interface between the two. We were concerned to select a product which had in-built support for RDBMS communications, and preferably considerable experience of working with Ingres to maintain communications within a reasonable timescale as new versions of software are released.

17.3.6.5 Network handling and traffic flows
Although not a direct requirement of the archaeological application, since the GIS would be used in connection with traffic modelling applications, eg the development of isochrones from journey-time data, efficient network handling was essential.

17.3.6.6 Support for input/output devices
In order to minimise set-up costs, the software had to support the existing peripheral devices, most of which are industry standard. The one piece of additional equipment recognised as an additional requirement was an electrostatic plotter to support the output of rasterised information.

17.3.6.7 Support for Data transfer formats
The single largest cost of developing almost any GIS system is the cost of acquiring the data. An important concern, therefore, has to be the ability to utilise any existing digital data within an organisation, to be able to use data acquired from other organisations and to export data either for exchange with external bodies or for use in other systems within the organisation.

17.3.6.8 Ease of use
Perhaps the single largest factor in selection was the ease with which the software could be made productive without compromising the technical capabilities of the product. Particularly with GIS software associated with macro languages, many

organisations have found the software difficult to operate and requiring considerable investment of resources before achieving any productivity gains. Because of the comparatively small size of the Data Team, it was essential that the selected GIS would be capable of operation by a range of staff without an excessive training requirement or long lead times on development.

17.3.6.9 Company stability and user-base
GIS is still a relatively immature technology, and an increasing number of software companies are offering products which have yet to become established. While the ability to migrate from a particular environment has been specified above as a criteria for selection, we felt equally, it was important to select a vendor with an established track record, substantial investment in research and development, an established UK user-base and support facilities, and preferably a strong European and US market share.

17.3.7 The GIS selected
While it is unusual for any software to perfectly fulfil a user requirement specification, the facilities offered by the Genamap suite of GIS software, produced by Genasys, came closest to satisfying our requirements. A satisfactory licensing agreement was negotiated with the company, enabling a mutually beneficial business relationship to develop.

17.4 SOFTWARE FACILITIES IN THE GENASYS SUITE

17.4.1 Introduction
There is considerable variation in the functional capabilities of GIS packages, though many GIS demonstrations often look rather similar. This section of the paper examines some of the functional capabilities of Genamap which may be of particular interest for archaeological applications. Although these cover many of the areas to which GIS has been applied, it is not intended as being an exclusive list.

Genasys, the company behind Genamap, is based in Sydney, Australia (though its offices are now distributed worldwide). The origins of the software lie in Deltasystems, a US-based GIS vendor which was subsequently acquired by Genasys. Genamap is a Unix-specific GIS, comprising an integrated suite of programs, consisting of Genamap, for continuous vector mapping, and network analysis; Genacell, for integrated raster and cell-based GIS functions; Genacivil for

civil engineering functions and Genagrave, a raster–vector conversion program. Further additions to this suite of programs are under active development. Genamap supports display of graphic and alpha numeric information in a number of formats. The preferred display is via an X–Windows environment.

17.4.2 Interface development

Genamap can be used interactively from a command line, or through a user–defined interface. Interfaces can be quickly developed using the GENIUS development tool, (GENamap Interactive User System), providing buttons, pull–down menus and scripts to perform pre–defined functions. Thus, it is possible to develop a system on which non–technical users can perform sophisticated interrogation of data.

Maps displayed in different windows may be related to one another, and data may be held in different projection systems and at different scales within the same database, analysing, overlaying and querying both data sets as continuous layers, even from different projection systems. This facility can also be used to focus on a specific area of interest. However, using an index map highlights some of the problems in choosing an appropriate map scale and the low standards of accuracy achievable digitising from small–scale map coverage. In digitising SMR sites in the West Midlands, for example, these were taken from a 1:10 000 base for speed of coverage. When re–plotted at 1:1250, many of the buildings (digitised as point data) did not correspond exactly with the correct building when overlayed against a hard–copy OS 1:1250 map. In practice, it is necessary to establish a sensible balance between the accuracy required, the time available for digitising, and the available map base.

Genamap can hold data as thematic layers, which can be queried for attribute information or for spatial analysis. For example, each of the six principal site groups in the character database standing structures, sub–surface remains, find-spots, historical ecology, cropmarks, and earthworks, could be displayed as a composite overlay on one window, while in another, one or more thematic layer(s) of the data can be selected and displayed, along with the feature tags or identifiers and a brief report sent to a report window. Polygons for example, taken within a detailed subset can be coloured or shaded on the basis of attributes within the database — by period, type or any other classificatory attribute.

Basic spatial querying, for example a radial buffer around a point, can be used to select fea-tures and the query may be defined to include all properties inside, outside, crossing, inside or outside and crossing the buffer boundary. A report can then be sent either to another window, to a file or output to a printer (for example, the addresses of all structures affected). Alternatively, the area of interest may be digitised on screen with a mouse.

The features which have been selected from a query form what Genasys term an "active ID", or spatial view of selected parts of the spatial database. In creating this, no data is copied and no temporary maps are created. In this respect, an active ID is similar in concept to indexes and spatial views in SQL databases. This is an important concept in Genamap, and is used extensively to perform manipulations. It is a very economical method of analysis since a physical temporary map is not being built, and an active ID may itself be the subject of further analysis, producing another map. At any stage, an ID can be archived as a permanent map.

The system can automatically generate a curved line buffer of user defined search distance. A selected feature may be displayed at greater resolution in another window. This facility is useful, for example, in reporting on implications of road widening proposals, or in analysing the effects of alternative transport routes. Not only does this provide the analysis of what will be affected, it also provides the basis for cartographic output, which can be of publication quality.

Information displayed in plan may also be displayed as a perspective view, with the X and Y angles specified by the user. Attribute data may be displayed as scaled bars on individual land parcels, or as pie charts. Graphs may be placed anywhere on screen to display frequency of defined attributes for example, land parcels by period, area or site–type. This can provide an impressive and easily comprehensible statistical map.

Vector and raster data can be transparently overlayed. For example, a raster image of an area may be combined with raw contours at a given spacing and used to predict the effects of changes in the hydrology. Potential applications for such a model would include examination of accessibility by riverine routes. We know, for example, in England, that waterways were far more extensive than in the present day, and formed significant transportation routes. Or from a planning perspective, examining the effect of changes in the water table as a result of operations by water authorities in the impact assessment on the preservation of environmentally sensitive sites.

173

While GIS can greatly improve the efficiency of development control procedures, it also has great potential as a research tool. This would be particularly effective if developed on a regional rather than county base. The use of GIS within SMRs may also give a more realistic capacity for in–house research. Many questions which are desirable to explore are currently beyond the capacity of county staff because of time constraints. One example would be viewshed analysis (the setting up of an intervisibility search between two points, on an n degree view). Applications of this technique include the examination of ritual landscapes, where the visibility of sacred monuments has, in the past, been deliberately controlled, and in monument management, assessing locations for visitor centres within archaeological landscapes, and the likely impact on the setting of monuments of new developments.

The software can produce a digital terrain model, enabling data to be "draped over" a landscape, utilising a roving window matrix centred on each cell searching for x,y,z data within that matrix. If a point exists within the cell that value is used directly and no estimate is made. If more than one value falls within a cell, the values are averaged. The software is genuinely 3 dimensional — the z value is held as a coordinate, not an attribute.

Finally, the system can accommodate scanned documents or other images. For example, a portion of text from an original hand–written document may be scanned and displayed. Once imported, the document may be dynamically displayed within a window and zoomed, scrolled and toned via facilities in the software. Such images may be stored with a feature link to a tagged feature. This means, for instance, that photographs of buildings may be linked to points or polygons representing such features on the map base. The rapid display of remotely sensed images can also be handled by this facility.

17.5 THE FUTURE FOR GIS

17.5.1 Summary
In summary, the three most crucial decisions for an archaeological organisation contemplating GIS where this is not being implemented as a general local government initiative will be:

1) identifying the user requirement (is this largely based on mapping, or analytical functionality)
2) selection of the digital map–base (potentially one of the most expensive system components)

3) identifying the cost/benefits of long–term investment in a period of change

While there appear to be few dissenters from the view that the relational database/GIS approach could significantly alter our understanding and ability to manipulate SMR data, enthusiasm for the technology must be tempered by some cautionary words.

17.5.2 Some words of caution
This paper mentioned at the outset the long lead time from inception of technology to implementation in local government and GIS is no exception. It seems likely that most SMRs will remain character–based until at least the middle of the decade, and it is not unthinkable to suppose one or two will still be running the mid–80's "Superfile" software then. Secondly, GIS systems are just as dependent on the quality of data, and the quality of analysis as any other database or mapping system and quality assurance procedures will undoubtedly be required on both.

For all the glamour attached to it, GIS does not, and is not, going to provide an off–the–shelf solution to archaeological research — it will simply broaden the range of possibilities, and the number of questions which we might want to ask. In connection with its research potential, it seems reasonable to suggest that if we are to justify investment in GIS, then this must be seen to be more than a simple planning tool for development control.

Although GIS may revitalise interest in the spatial analysis so popular during the 1970's, the analytical techniques available require further development. Spatial functionality in many GIS systems is limited; in some cases, systems do not accommodate quantitative geographical techniques available in the 1970's. On the other hand, many of the algorithms used are implemented as black boxes, which means their impact on particular types of data may be uncertain.

The training needs for GIS should not be underestimated. While Genamap is a comparatively "user–friendly" GIS, the training requirements for developers and end–users are an expensive and normally an unavoidable element in addition to any software license charges. In the short term, personnel with archaeological and GIS training will be in short supply, and hence staff turnover may threaten system maintenance and development.

Perhaps most importantly, the availability of relevant information is restricted. National policies, charging policies, attitudes of users and re-

strictive access all place constraints on data acquisition. The alternative, digitising of information in–house, can be time–consuming even where adequate (and non–copyrighted) hard copy data exists. This applies particularly to the availability of map bases. A minimum base–map requirement for an SMR as being 1:10 000 scale has already been mentioned, while an urban SMR will require a 1:2500 or preferably 1:1250 map base. Currently, this is not available for the whole country in vectorial form, though most principal towns and cities are now covered. Full countrywide coverage is unlikely to be available until the next century. Furthermore, the vectorial maps supplied by OS are not currently topologically structured (free of digitising errors producing "clean" points, lines and polygons) and require extensive editing to achieve this.

17.5.3 Conclusion

In conclusion, there are many more questions than answers posed by GIS. Given the time–lag that has been demonstrated between the recognition of software potential and effective implementation, it is reasonable to consider whether GIS will still be "current" technology if, indeed, there is a time when it will be in common use by SMRs.

If we compare progress with character–based database technology, SMRs were still starting out on database software (such as Superfile) in the later 1980's when that had long been superseded by considerably more powerful products, but at the time of Superfile's selection by English Heritage at the beginning of the decade, it offered quite sophisticated functionality and had few competitors which could operate on the required range of hardware and operating systems, a point often overlooked by its detractors.

Finally, in a time of considerable change in the structure of local government, the organisation of archaeological services is likely to be a low priority. The particular demons which may emerge as a result could very well be legion, and the semblance of structure achieved during the 1980's may soon be torn asunder.

Whatever the future holds, we may take some solace from T.S. Eliot, remembering that:

"We shall not cease from exploration
And the end of all our exploring
Will be to arrive where we started
And know the place for the first time."
Eliot, The Four Quartets, Little Gidding V.

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