CHAPTER 11

MAPPING THE HERITAGE INFORMATION LANDSCAPE: INTEROPERABILITY AND GEO-SPATIAL DESCRIPTION IN THE MANAGEMENT OF EUROPE'S HISTORIC ENVIRONMENT

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1. INTRODUCTION

It is a truism that while the disparate national and local heritage services of Europe represent different traditions and experiences of recording, presentation and management, this diversity risks misrepresenting the past. While contemporary heritage services work within the constraints of modern political boundaries, such boundaries were largely irrelevant to prehistoric or later populations. Topographical features apart, the outlines of the modern political landscape of European nation states are little more than 1,000 years old, and in most cases significantly more recent than that. These modern divides risk embedding anachronistic divisions between ancient populations who moved freely across the borders that we now police.

This paper investigates the long-standing question of how different heritage services in different parts of Europe may work more closely (*inter alia* Hansen, 1993; van Leusen & Prinke, 2001). In particular, it concentrates on how different national and local heritage records may support management and research decisions in places far removed from their original locations. Reliable up-to-date information is the principal tool of good management and good research, so it follows that, if we wish to seek to develop more integrated heritage management policies across Europe, then we need also to develop tools that will help to integrate our information resources. Yet this is an ambitious task. Consequently, I will not risk identifying a single solution, but discuss various paths that may lead to the same goal. A focus on the process of interoperability will reveal weaknesses within existing models that cannot be overcome easily. The deployment of geo-spatial description does, however, provide a platform for an alternative approach. Thus instead of considering the heritage record as a series of databases we should instead conceive of it as a map. Re-casting the European heritage record as a map brings its own challenges, which will be presented. However, a number of initiatives in a variety of countries encourage us to recognise that certain of the necessary tasks are already in hand. We may seek to influence developments, but some aspects can only be resolved from within the archaeological community. This paper does not seek to provide a specific conclusion *per se*, so much as to identify some of the challenges and opportunities that we face.

2. WHAT INTEROPERABILITY CAN DO

The "information age" has many contradictions. On one hand, the prospect of access to an infinite library of knowledge at the click of a mouse sounds like an irresistibly compelling vision. To some extent, the Internet already provides that (seemingly) infinite resource, but experience shows that the sheer quantity of information available confounds retrieval. If we cannot find the information we need, then we cannot hope to use it. The situation already seems unmanageable, with even the most reliable search engines failing to do anything more than scratch the surface of information actually available. Time will not fix the cataloguing backlog: if anything it will become worse. One recent library study has shown that the world produces some 250 megabytes of information for every man woman and child every year –between one and two 'exabytes' of information, the equivalent of 1,5 billion gigabytes or $1,5(10^{18})$ bytes per year, much of which finds its way to the Internet (Lyman *et alii*, 2000). The Internet is thought to contain something in the region of 4 billion individual pages at the time of writing, and may well hold some 8 million by the time this paper is published. Significantly, the Internet is not just still expanding, but is growth rate is accelerating (Moore & Murray, 2000). How, given this extraordinary growth, can we rely on computer networks to connect us to the information that we actually need and want?

Archaeology is no exception to the rule. In 1994, Southampton University was exceptional insofar as the Archaeology Department mounted a series of web pages with a range of content, including e-publications. Now, it seems inconceivable for a university department not to have a series of web pages. Though only a small number of heritage services in Europe actually provide electronic access to their data sets, almost all have some plan by which they will ultimately release parts of their digital record on the Internet. As with the Internet more generally, the proliferation of web services represents a welcome development for research and management, but also presents its own challenges.

By way of example, imagine a researcher or heritage manager in some far-flung heritage agency undertaking some work on the "limes" of the Roman Empire. Clydebank, an industrial suburb of Glasgow, seems a rather unlikely place to find important evidence for this, but, as the western end of Rome's most northerly frontier, it has some claim to being the top left hand corner of the entire Roman Empire: the farthest point on the farthest frontier. Thus, despite its rather humble appearance, the buried archaeology Clydebank presents a peculiar case of heritage management with local, national and international implications. There is in fact a great deal of information about the Antonine Wall already available on the Internet. If a researcher wanted to know how the sites associated with the western end of the Antonine Wall were managed, or what state they were in, the researcher would have a whole range of information available to them.

The National Monuments Record of Scotland would be a good place to start: this has an electronic web version available at http://www.rcahms.gov.uk/. The Clydebank area falls under the direct protection of the West of Scotland Archaeology Service that also has a proto-type web server allowing access to the West of Scotland Sites and Monuments Record at http://www.wosas.org.uk/. In addition, the Scottish Cultural Resources Access Network has used significant amounts of money to develop access to "cultural resources", including evidence of the Roman fort in Old Kilpatrick, near Clydebank. SCRAN make these available through their website at http://www.scran.ac.uk/. In addition, many of the finds from the Antonine Wall have made their way to an exceptional collection at the Hunterian Museum, which has a permanent and interactive electronic exhibition about life on the Antonine Wall (http://www.gla.ac.uk/museum/). Finally, though not fully available

at time of writing, the Cornucopia project is working to facilitate access to UK museum collections. Their web database of museum catalogues (http://www.cornucopia.org.uk/) will ultimately be able to identify the final resting place of things like the mile slabs that accompanied completion of the Wall.

One question on a relatively obscure but important area thus presents at least five high-quality digital data sets that will be important to answer any number of questions. Each has its own view on the same basic data set, configured for its own purposes. Each has its own communications strategy encouraging users to visit the web site. Each of the data sets ultimately has to prove its utility by providing information to an identifiable number of users. Yet the user, who may or may not know about all the different possibilities, is badly placed to sort out the different and sometimes competing information that is presented. Currently, data providers offer a range of interfaces and support to complementary data sets. This has consequences for the user and the distributor. The user has to negotiate each of these interfaces, and has little option but to bring the different data sets together manually. The mix of service provision presents an obstacle to the use of that data. If the data is not used, implications follow for the data provider too. SCRAN, for example, is partially commercialised, so failure to reach users is a serious impediment to the success of the organisation's business plan. All of the services, however, need to demonstrate their competence by demonstrating a growth in "hits". So, failure to develop a user community will ultimately harm the success of the web site strategy.

Serial searches and multiple interfaces are not just an impediment to users and providers alike, they are also unnecessary. Interoperability holds out an answer to the provision of data in a form the user can dictate through an interface with which they feel most comfortable. If we can build the correct information architecture, we can overcome many of the problems of information overload with which the information technology presents us.

A number of systems exist that can, if developed well, ease the strain. At a very high level, a variety of semantic schemae exist that could provide a seamless information landscape that would not only manage information, but will ensure that it is legible by the variety of devices we use to read that information. A sixth generation of mark-up language for web pages –the extensible mark-up language (XML) offers the potential to create a "semantic web" in which information can not only be retrieved easily but can be processed in such a way that the data we receive is in fact the data we need. The concept of the semantic web parallels wider developments towards interoperability of data sets. A variety of information tools such as Z39.50 (Miller, 1999), the Open Archives Initiative (OAI) (MacColl *et alii*, 2001) and the Dublin Core metadata standard (Miller & Greenstein, 1997) are designed precisely to allow information to be processed in such a way that different data sets, with different structures and different ostensive subject matter can be interrogated simultaneously, without having to revise the data structure of the native data set. Interoperability, conceived of as mixed economy of indexing schema, communications protocols and transmission formats, is seen as the way forward, even in the highest level of government (Miller, 2001).

Within archaeology, the Archaeology Data Service (ADS) has been at the forefront of developing and encouraging interoperability between archaeological datasets and datasets of interest to archaeological researchers (Richards, 1997). The online catalogue of the

ADS –ArchSearch– provides a model for how interoperability can indeed be achieved between disparate archaeological records (http://ads.ahds.ac.uk/catalogue/). The catalogue presents a single interface to a mix of databases as diverse as the National Monuments Record for Scotland, the Greater London Sites and Monuments Record, the English Heritage Excavation Index for England, the Northern Ireland Sites and Monuments Record, the Clwyd Powys Sites and Monuments Record and the Index to Radiocarbon Dates for Britain and Ireland and many others besides. Thus, ArchSearch provides proof of the concept of interoperability within archaeology, and shows that, if done thoughtfully, archaeology can indeed develop uniform interfaces to data across local and national boundaries.

ArchSearch works by indexing the various records within the disparate data sets to a uniform standard –the widely used Dublin Core metadata element set (Miller & Greenstein, 1997). This index, then acts as an index to all the different databases and data sets that are available, providing on-line links to those that are available online, and indications of how to obtain records that have not been released for whatever reason. Having established a standard for the implementation of the metadata element set, this system requires nothing more than an enterprise-level database server and the good will of the various partners that want their own datasets to be made more accessible. Searches in the database appear to search the different, distributed databases, but in fact they simply search a single local database that indexes the others. Because the metadata index includes detailed geo-spatial description, a map-based interface is also possible ensuring that all the resources can, depending on the quality of the information supplied, be retrieved by geo-spatial description.

A second generation of interoperability is imminent, through the development of HEIRPORT, a new historic environment portal for archaeology that carries out truly distributed searches using a variety of tools including XML and Z39.50 (Austin *et alii*, forthcoming). This system will extend the mix of inter-operating services available through the ADS to include SCRAN, thus creating a single interface to a whole range of resources that are made accessible through the same interface as soon as they are created. Moreover, Z39.50 allows any number of services to create their own view of the datasets presented –so each institution or individual could, in theory at least, build their own map of the information landscape which was relevant to their own needs at any given time.

3. WHAT INTEROPERABILITY CANNOT DO: LANGUAGE PROBLEMS

Interoperability is thus not only theoretically and technically possible, it already works. The continuing rapid growth in demand for the ADS catalogue shows that there is a demand for such a system (Kilbride & Winters, 2001). Yet it would be foolish to suppose that this was somehow a simple solution that could be extended right across Europe to provide a common market for archaeological datasets. There are a number of significant issues that stand in the way of such seamless integration. As well as the simple logistics of organising and committing a sufficient number of partners to make the work worthwhile, there are significant technical obstacles to be overcome also. Moreover, and perhaps more importantly, this assumes that we even want to undertake this work.

The existing ADS model of interoperability appears to offer the opportunity to bring datasets together from disparate recording practices and across local, regional and international borders. Yet closer inspection reveals that this is only partially true. While 'ArchSearch' and 'HEIRPORT' do offer such functionality, they currently only present data from English speaking countries (UK and Ireland), or records created by UK-based researchers who present their work in English. This means that, though the technical architecture of the ADS system is extensible to wider context, the information architecture is limited to the extent of the English language. Consequently, while it may be possible –even tempting– to develop a European portal for heritage records, the practicalities of search and retrieval using natural language mean that such a portal would be unable to present meaningful results users. Only a very small fraction of the relevant community would be able to understand and use such a portal effectively. It is hard to quantify the figures exactly, but it is hard to imagine that there would be more than a few dozen users able to make sense of a truly multi-lingual portal. It would be hard to justify the investment of time and effort against such a meagre return.

The problem of language is not insurmountable, though it will take a significant investment to be resolved. There are a number of possible solutions that will go some way to alleviate the problems. One of these –geographic description– is soon to become the principal subject of this paper, but it is worth spending some time considering the other possibilities. On one hand we may chose to spend a lot of time and money to resolve the language problems that we identify. On the other we may simply abdicate the problem, transferring it to the user community. These are the two ends of a continuum that describes how much user support we are prepared to offer.

The idea of multi-lingual information tools is not new, even in archaeology. A number of projects have already provided the proof of concept that multi-lingual search and retrieval tools can be developed, though there is little experience in actually implementing such systems in the routine of daily work, let alone within a web environment. The ArchTerra project has presented a series of tools for multilingual web browsing for the Archaeological Resources Guide for Europe (ARGE) (van Leusen & Prinke, 2001). Similarly the council of Europe has funded work towards the creation of a multi-lingual thesaurus of the Bronze Age that, if implemented, would allow European museums to exchange information about certain classes of artefact (Hansen pers. comm.). Also, work has been continuing on the Herein project that has spawned a variety of bilateral working groups that have created a small, but dearly won vocabulary of terms suitable for exchanges between a variety of European languages.

Experience gained on such projects shows that multi-lingual tools are expensive to orchestrate and are labour intensive, even for a small expert group (Grayson pers. comm.). Moreover, the effective lack of implementation of the few existing exemplars suggests that the proposed benefits are not guaranteed. However, the European Union is explicit in its desire to foster the development and implementation of a variety of multi-lingual tools. This means that, though multi-lingual tools may be difficult to use and develop, they are, at least, consistent with broader policy objectives, and thus may be more attractive to funding bodies than first appearances may suggest.

Other sectors, however, have been more successful at developing such multi-lingual tools, such as the European Law Portal Eurlex, which benefits from the investment that the EU makes in terms of translation and interpretation. At a technical level, a number of software tools exist which not only allow distributed databases to be connected, but for the vocabulary controls to be located and interrogated remotely too. The Z-thes project is a case in point of a thesaurus for terminology control being made interoperable, and thus independent of the databases that it is used to manage.

An alternative departure for multi-language search and retrieval is provided by the Hitite project, which is working to illustrate the English Heritage Thesaurus of Monument types (Carlisle pers. comm., Lee pers com.). This project steps aside from natural language search and retrieval problems by configuring the search interface to be image intensive. Thus, rather than identifying database objects by language, it offers users the opportunity to compare their own (unknown) class of monument against an image of a known class. This system still depends to some extent on the use of natural language, and multi-lingual tools are still needed to make it work. It provides an ingenious model for overcoming some of the problems. The side step will, to some extent, restrict the functionality of the data, but this is an appropriate move given the specific aims of the project. The use of images does present an alternative model for database search and retrieval more generally, but it is hard to imagine that sophisticated extensible content-based image retrieval would be any cheaper than multi-lingual tools, and considerably less intuitive.

Thus, while interoperability can present some solutions, it would be foolish to suppose that the technologies currently available can really allow us to build a single (let alone a whole number) of portals to archaeological data across Europe. There is a solid body of developmental work that may, if we chose, take us in that direction –but there is still a lot of ground to cover. If we are to develop such a network based on multi-lingual tools, then we have a lot of work to do. That work is not impossible, but it is clear that a number of priorities will have to be established, and a significant number of test beds and exemplars supplied first.

4. GEOGRAPHIC DESCRIPTION

Geo-spatial location is, of course, pre-discursive in archaeology. It provides a common language that we often take for granted. The location of sites and monuments is often as important as their actual construction. This is as true of formal academic research as it is of heritage management and mitigation work. Geo-spatial description is a universal description. The description of a unique place expressed with precise and accurate grid references is, at least in theory, inter-changeable with any other description, provided similar standards of error and accuracy are tolerated. Though different forms of grid references are used in different countries in Europe, and indeed within different countries, the properties of the diverse projections and systems are well known. Thus, the Great Britain National Grid and the National Grid for Ireland are complementary, with similar tolerances of accuracy and precision derived from similar projections, but off-set by a fixed constant. A location articulated on the Irish grid can be readily transformed to the Great Britain grid by reference to a known mathematical function. Both can be expressed in terms of latitude and longitude. So long as certain properties of the data is known (aka metadata), the task of transforming and re-projecting is a complex but

manageable exercise in mathematics: precisely the sort of procedure at which computers excel.

All is not so simple, however, since the majority of geo-spatial description of information is not presented in terms of co-ordinates. Grid references and map projections are widespread in archaeology, but are by no means universal. Thus, for example, the CIDOC draft standard for core data within sites and monuments records omits co-ordinates from its repertory of required fields. This is in part a response to the needs of the time. In the early 1990's, when the standard was drafted, GIS were unusual in any country. The draft standard is explicitly designed as a tool for those countries that wish to develop monuments records from scratch. Consequently the thought of imposing standards required by only the most advanced systems (at the time) would have run contrary to the broader ethos of the document.

More generally, however, a variety of standards are used to describe geo-spatial location without reference to map ordinates. For example, population censuses in the UK are collected in a series of hierarchical entities which are consistent with the needs of the census bureaux, but which are not inherently "map-able". A more convoluted transformation is required whereby the outline of each census district, such as post code area or civil parish are used to define the census polygon. These secondary data sets provide an essential support if such data is to be analysed in GIS, acting as a gazetteer to the geo-spatial co-ordinates of the data. Geo-spatial gazetteer services which connect a place name to a numeric "footprint" are the only practical way to handle large quantities of textual data in a GIS environment.

The problems of making geo-spatial descriptions constant have exercised the geographic information community for some time now. A number of working groups have been formed to identify and agree standards in geo-spatial description, as well as ways of supplying information. Thus, in the UK, the National Geospatial Data Framework has identified a basic set of elements that provide a core description of a geospatial data set (www.ngdf.org.uk). Other initiatives in other countries have undertaken similar work, such as the US FGDC, and ESMI. These initiatives provide detailed model for the exchange of metadata that in turn allows for the competent search and retrieval across disparate collections –geology maps, terrain models, population data and the like. These recording systems do not offer a panacea –they do not undertake the overlays that researchers or manager may in the end wish to do, nor do they even mean that the various coverages are in fact available for use in any given context. However, they do at least show the resources that *may* be available to researchers or heritage managers concerning any given location. Archaeology would be well served in using some such collection level description to identify the broad outline of the data that we hold.

We can however do more than just tell people the extent of the datasets we may have. The investment in GIS technologies by groups outwith archaeology means that sophisticated tools already exist for interoperability of geographic datasets. In the forefront of such developments are the Open GIS consortium (OGC) who have offered a sophisticated specification for GIS functions. This OGC specification may be imagined as a common language for geo-spatial processes, and as such it creates the potential for a distributed environment in which different computers may undertake different elements of a single process. Thus, for example, coverages may be called up from remote servers, then overlaid by a third machine which supplies an image for use in a client's browser. It would be naive to underestimate the processing overhead associated with this sort of networking, nor should we under-estimate the real costs in time, money and institutional involvement. Even so, such tasks are only practical in a distributed environment if based on open standards. OGC provide the GI community with such standards.

In addition to tools for resource discovery and information processing, work continues to provide an information model to supply data across distributed networks. The extensible mark-up language (XML) has already been mentioned as one of the favoured solutions for bringing disparate data sets together. XML already has a number of derivative products that might be considered as applications or implementations enhanced for specific purposes. X3D for example is an extension to XML designed for the exchange of virtual reality data sets (Fernie *et al*, forthcoming). More relevant to this discussion, however, is the recent development and imminent deployment (in the UK at least) of OGC's GML –Geo-spatial Mark-up Language– an extension of XML designed for the exchange of geo-spatial data. GML may be thought of as a file format that is more flexible than many of its equivalents. Because it is XML based it may be used in the same way, using transformation processes to extract the relevant pieces of data for purposes as diverse as in car navigation, mobile networking as well as conventional mapping. GML is bound to have an impact on the UK at least, since it has been identified as the format of choice for the supply of map data from the emergent Digital National Framework.

As well as open file formats, open standards for information processing, and formal mechanisms for cataloguing resources, commercial developers have been quick to exploit these opportunities. ESRI, for example, who partly sponsored this conference, have released an internet mapping server called ArcIMS which offers desk-based GIS functionality within a web environment. Such sophisticated products are yet to have much impact in archaeology, though it will only be a matter of time before they become more visible. Two major projects in the UK –the Cambridge University Committee for Aerial Photography and the Multiple Agency Geographic Information for the Countryside Consortium– have already committed to ArcIMS as their interface of choice. Other similar products are available, suggesting that web-based GIS is not only theoretically possible, but imminent.

Thus, the management of Europe's heritage depend, to some extent, on access to reliable and up-to-date information. If we are to integrate heritage management policies, then we will look to tools that help to integrate our data sets. However, existing models for the inter-operability of data sets cannot resolve theses issues without some considerable investment in tools that will allow us to speak all the different languages in which our diverse records currently reside. Space is the common language that we already take for granted, so presents unique opportunities and challenges for a model of interoperability. Developments in geo-spatial technologies mean that some of the standards, tools and infrastructure necessary to embark on the process already exist.

5. CHALLENGES FOR MAPPING EUROPE'S HERITAGE

Before getting too excited about the limitless possibilities and ambitious developments, it is wise to utter a few words of caution. A number of significant challenges still exist, and we are well advised to be aware of them.

The development of sophisticated GI technologies and standards for the exchange of information does not mean that we are well equipped with mapping. Mapping remains expensive, meaning that the development of sophisticated GIS tools depend on a significant investment. Electronic supply of mapping data varies across the continent, and the complexities of copyright and related intellectual property rights makes lawyers and mapping agencies rub their hands with glee. These problems persist in conventional desk-based environments, but are nothing in comparison to the complexities associated with a distributed environment. Web or networked services present particular challenges to obtaining mapping data. Such problems can normally be overcome, but only at very large expense. The costs currently associated with web-mapping depend on the use we seek to make of it. Simple raster mapping at coarse resolutions can be obtained relatively easily, but more detailed raster mapping is expensive. Vector mapping, which is essential if we seek to undertake more sophisticated GIS functions, is prohibitively expensive, even at larger scales. The development of pan-European heritage management tools depends, in part, on the existence of pan-European mapping data. Ambitious Internet plans to develop the functionality we are accustomed to on our desktops face a serious impediment. The impediment grows proportionately with the size of the ambition.

The costs of mapping are not the only practical barrier. The computing infrastructure at our disposal is variable. Networking data sets means networked computers, which has an implication for the use of the Internet across Europe. Internet access is readily available in all of the member states of the European Union, and the bandwidth available continues to expand, though the amount of traffic keeps pace with the expansion. The same is not true in all of Europe however. These practical considerations also have implications for the development of a Pan-European information architecture for heritage records. The problem has been recognised in the Commission who now include "pre-accession" countries of Eastern Europe within the scope of their funding programmes for digital projects. Even this extension, however, cannot resolve the problem in its own right, since the use of digital networks utilise so many interdependent elements that the only way to guarantee high speed networking is to lay the cables ourselves. This is precisely what the UK higher and further education sectors have done, but the costs involved are enormous. The situation seems bound to improve, but in a piecemeal fashion. Ironically, it may well be that those countries which would benefit most from access to heritage data sets that may find it hardest to obtain them. In short, therefore, the provision and use of integrated data sets will reflect realities of our local infrastructures.

The variability in networked infrastructure and the costs and availability of mapping data are both strong reasons for moderating and tempering our ambitions. For any network to be a success, it must offer something to all parties. We should therefore expect to compromise some forms of sophisticated functionality against reliability. Such a compromise would serve us well for other reasons. It is rarely articulated, but seems widely acknowledged that the heritage management sector finds it hard to recruit and retain the skills necessary to support the sorts of enterprise level applications that we seek to develop. This is not unique to communications and information technology, but is true of many aspects of the sector, including project management and administration. To put it bluntly, if we have unrealistic ambitions then we had better budget for unrealistic salaries too.

The practical problems associated with computing infrastructure, staffing and map data are essentially external problems. They are related to the work we do, but do not ask us to change in any way our existing working practices. Yet the use of space as a platform for interoperability has implications for how we record sites and monuments, and will depend on a review of current working practices and in some cases enhancements to existing records. García Sanjuán and Wheatley have recently reviewed the use of GIS in heritage management, noting the mixed economy that exists (García Sanjuán & Wheatley, 1999). The use of GIS for heritage management implies certain ways of thinking about records, and specific forms of information: García Sanjuán and Wheatley show that this approach to records is not uniform across Europe, but varies in response to local needs. Sites, monuments and landscapes may be expressed in a variety of forms, but in all cases, a mathematical expression of point line or polygon (or all of them together) are essential if a GIS is to function at all. If, in contrast, the record depends solely on a relational database, and if mapping properties are not included at the outset, then there is every possibility that the sorts of co-ordinate data necessary to produce a GIS overlay will be overlooked. Consequently, if we seek to integrate heritage management records on the basis of geo-spatial co-ordinates, we may in fact have to generate co-ordinates. Thus, geo-spatial location as a platform for interoperability assumes the existence of data that may not in fact exist. The benefits of a GIS approach as against a database approach are well documented (Fernie & Gilman, 2000), so the generation of such data serves well the interests of all parties, not least the managers who use the data on a daily basis. However, given the competing pressures and demands that we face, the production of such co-ordinates presents another unwelcome obstacle.

Map references, however, are not the only piece of information needed if we are to bring records together in some way. Even where they are routinely recorded, map references necessarily contain errors that frustrate and hinder the deployment of GIS techniques. At a very basic level are simple recording inaccuracies and imprecisions, inevitably present in any data set. Records may simply be erroneous, however precise they may appear to be. So a reference that purports to describe a find spot to within one square metre may be extremely precise, but if it refers to the wrong square metre, then it is inaccurate. By the same token, we may locate the find spot accurately on a map, but if the map is at the scale of 1:500,000, then it is accurate but imprecise. We may have co-ordinates, but these are difficult to use without some measure of precision and accuracy.

Errors are not simply the product of inadequate recording practices. Mapping is by its very nature an attempt to summarise and simplify space and so mapping means a degree of error. A precise and accurate grid reference is only as good as the grid on which it is plotted. The errors associated with such grids are known, so some of the necessary transformations can be automated as numerical processes. Even so, maps often contain internal and random variations that are the result of the variable topography they represent. Thus, as well as general problems with map projections, the irregular surface of the earth means that distances measured on its surface may be erroneous —even after we correct for the projection. Thus, as well as presenting the errors associated with cartographic regime in use, a more subjective confidence factor may still be needed to articulate inconsistencies that may not be so obvious.

6. OTHER CHALLENGES, OTHER SOLUTIONS

This paper has looked at the issues associated primarily with using geo-spatial technologies to create an integrated interface to Europe's diverse heritage records. There are other, more fundamental problems that should not go un-stated. Firstly, a paper from the Archaeology Data Service would not be complete without at least one mention of the problems of archiving. Secondly, this paper has, to some extent, assumed the form and nature of the heritage record. The form of the record should not go unquestioned, even though this is beyond the scope of this paper. Finally, this paper has assumed the identity of the organisations that manage our records and make them available. Research suggests, however, that there are many different records that we may choose to investigate (Baker *et alii*, 1999). Even tracking down and making available the names and addresses of all the relevant records would be a significant step forward.

The long-term preservation of data remains a significant challenge to information managers (Ross, 2000). The Archaeology Data Service has been privileged enough to facilitate applied research in this field over the last few years, bringing together the subject specialists of archaeology with best practice in digital preservation generally. The result has been a raft of guides to good practice, policy documents and case studies which show the need for integrated archival policies, provide models for how that may be achieved and raise awareness in the community in general. GIS data presents particular problems for presentation on account of the complicated data structures used and the intricacy of the intellectual property rights which accrue (Gillings & Wise, 1999). Having heritage records in the form of GIS is one thing, but ensuring that the investment of time and effort that they represent will still be available in the long-term is quite another proposition.

The heritage records currently used across Europe vary in their size and complexity, but they follow a similar model. The CIDOC draft standard for sites and monuments records focuses attention on discrete locations within landscapes, rather than landscapes in their totality. It does not rule out landscapes as part of the record, but these are, to some extent subsidiary. However, as heritage managers, we are concerned with the look and feel of the entire historic environment, not just discrete parts of it, so there may be grounds for questioning whether the idea of a site or monument is really an appropriate model. Certainly GIS encourage us to think of sites and landscapes in different ways from monument inventories, to look more closely at landscape classifications or extensive surveys in different ways that draw upon records of sites and monuments, but which are greater than the sum of their parts (Dyson-Bruce pers comm., Thomas pers. comm.). In planning the pan-European strategies to share information, we should not only be aware of local variations, but we should be alive to the idea that the idea of the sites and monuments record is itself fluid.

This paper has assumed a ready-made and known set of records, represented by the participants of the workshop. In reality, however, it is difficult to know what records that there may be. The devolution of power to Europe's regions, and the role of planning within local as well as national government means that the most important and up-to-date heritage records in fact reside with a multitude of local, national and international organisations, depending on local knowledge, subject specialisms. If inter-operability through geo-spatial location is overly ambitious, even just knowing who to ask for records about a particular place would itself be a useful resource. Collection level descriptions of the various records are an essential element in any attempt to make our records more accessible to each other (Kilbride, forthcoming).

7. CONCLUSION

This paper seeks to identify challenges and opportunities, rather than solutions and answers. Information is our key mechanism for management, so if we move towards pan-European heritage management, then it will be necessary to think about pan-European information architecture for our heritage records. There are a variety of tools and technologies which may enable us to develop such an architecture, though each of these bring challenges of their own. The use of geo-spatial description may allow more rapid development than other, established models of interoperablity because space is the one common language which we all use and with which we are most familiar. Our modern political divides risk embedding inappropriate divisions within the management of Europe's heritage. Eliminating or negating the impact of these modern divisions is made easier if we recognise that Europe was a single geographic entity long before it thought of being a political one.

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