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Developing a Spatial Data Infrastructure for Archaeological and Built Heritage*

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Abstract

Although the INSPIRE Directive provides a roadmap and technical specifications for providing interoperability of spatial information created and held by public bodies across Europe, its relevance to archaeological and built heritage information is unclear. Whilst there is a clear need for access to information about the historic environment by a range of audiences actively engaged in the management of Europe's rich heritage, delivery of relevant services is restricted to a narrow interpretation of the Annex I Protected Sites theme that focuses on statutory designations. This paper explores business reasons for adopting a more expansive interpretation of what information should be considered as and distributed as part of the Protected Sites theme in order to support policies and activities that impact upon the wider historic environment. The paper also considers the range and potential of information created through investigation and recording of the historic environment, often at public expense or interest. The potential for data reuse generating savings, inspiring smarter working practices, and developing sustainable datasets is explored through case studies from Scotland and Ireland and proposals to establish a thematic geo-portal, web services and applications through the EU Culture funded project ArchaeoLandscapes Europe (ArcLand), are discussed.

Keywords: Protected Sites, Historic Environment, Cultural heritage, Archaeology, Remote Sensing

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1. INTRODUCTION

The understanding, protection and management of Europe's shared and varied historic environment is dependent upon the integration and analysis of information and data. Whilst INSPIRE addresses the need for Spatial Data Infrastructures and data interoperability, much of the focus of research and development is upon how best to manage and share the distribution of natural environmental and security/asset information. Consequently there is a low level of awareness and engagement with INSPIRE amongst historic environment specialists.

Knowing location is essential in documenting and protecting the archaeological and built heritage. Through location, defined by co-ordinates, spatial extent or for much of the built environment by address, information about heritage may be shared with non-specialist users, such as developers and planners. In this way heritage may be considered alongside other environmental datasets as well as being appreciated by the wider public through tourism and leisure. Other characteristics also help inform the interpretation of the historic environment. Documentary references, architectural details on a building or its interior fittings and furniture, the form of a monument, investigative techniques including aerial survey, remote sensing and excavation as well as artefact and ecofact analysis all contribute knowledge and inform interpretation. For specialists, location adds value to these attributes. When presented spatially, results of field survey, remote sensing or excavation adds detail to location information defining the extent of a monument. Information from previous investigations should, in turn, inform future research and as more spatial information is created, it should also be preserved for reuse by future researchers. From the academic and scientific perspective, location has long been important in the analysis of settlement and in palaeo-environmental analysis. Information about the historic environment must, therefore, be tailored to suit multiple audiences, ranging from those needing to know about assets and constraints to those engaged in research and study.

This paper explores aspects of the historic environment and cultural heritage, primarily the locations of archaeological sites and monuments, as well as the industrial and built heritage and information that helps define their location. Information from field survey, excavation and increasingly remote sensing (Bewley, R et al, 2005) all contribute to define a monument and can be considered as part of a richer dataset that informs location. The paper does not specifically discuss artefacts associated with a monument or building, although these objects may re-acquire location through association and form part of a richer network of data outside the scope of this paper, increasingly accessible through Europeana (http://pro.europeana.eu/ [accessed 12 February 2012]) a portal presenting digital content including museum objects, archival records, music and film, from over 1,500 of Europe's heritage collections.

Through Council of Europe conventions, signatory states are required to maintain inventories of archaeological sites and architectural monuments, some of which (but not all) are protected through legislation. Although there is a clear mandate to publish information about those sites that are statutorily designated through the Annex I Protected Sites theme under INSPIRE, there is uncertainty and ambiguity over the relevance of information about the wider archaeological and built heritage.

Arguments for adopting a more expansive interpretation of the Protected Sites theme beyond designated assets are outlined to support a strong business case for volunteering information to complement the mandated datasets.

Looking beyond publishing information which defines the archaeological and built heritage, consideration is given to the range and potential of information created, often at public expense or interest, during research and investigation of the historic environment as part of Annex II or Annex III themes. The potential for data reuse generating savings, inspiring smarter working practices, and developing sustainable datasets is discussed through two case studies.

- Royal Commission on the Ancient and Historical Monuments of Scotland. (RCAHMS) – The collection, management and dissemination of public heritage information for Scotland.
- The Discovery Programme – The collection, management and dissemination of archaeological research data within Ireland and realising its full potential with external organisations and the wider research community.

The case studies demonstrate the need to share information more widely with other professionals working in heritage and with other public agencies concerned with protecting the environment. This will not only help in the preservation and management of the cultural heritage but will also deliver efficiencies in stimulating research across national borders. The need to establish a thematic approach to coordinate the sharing of information about Europe's rich and shared cultural heritage is explored. The EU funded Archaeolandscapes Europe (ArcLand) project aims to address this need through a thematic geo-portal, web services and related applications.

2. PROMOTING THE WIDER HISTORIC ENVIRONMENT

The core vision behind INSPIRE seeks to develop a common infrastructure for spatial information across Europe to support community environmental policies, and policies and activities that may impact on the environment. INSPIRE and developing national and regional Spatial Data Infrastructures should be the

catalyst to enable those responsible for the documentation and curation of the archaeological and built environment to contribute to and benefit from that vision.

The benefits of publishing historic environment data through INSPIRE have been recognised in Scotland by both Historic Scotland, an executive agency of the Scottish Government charged with safeguarding Scotland's historic environment, and RCAHMS. Both organisations are fully engaged in the implementation roadmap and have published metadata for their key services on the Scottish SDI Discovery Metadata Catalogue (http://scotgovsdi.edina.ac.uk/srv/en/main.home/ [accessed 12 February 2012]) as part of the Protected Sites theme. Historic Scotland is responsible for implementing Scottish Ministers policies for statutory (Scheduled Monuments, Listed Buildings and Conservation Areas) and non-statutory designations (Gardens and Designed Landscapes and Historic Battlefields) (Historic Scotland (2011)). For these datasets there is a clear mandate to deliver metadata and services under the Protected Sites theme. RCAHMS maintains Canmore, the national inventory of the archaeological and built heritage of Scotland and its maritime waters (http://canmore.rcahms.gov.uk [accessed 12 February 2012]). Canmore holds over 300,000 records ranging from archaeological sites to architectural monuments and maritime losses, of which only a small proportion are formally protected through designation. For the archaeological component of the inventory, it has been suggested that scheduled monuments represent about 7% of the archaeological records held in the RCAHMS database (Swanson 2001). Scottish local authorities also maintain Sites and Monuments Records (or Historic Environment Records) complementing the nationally maintained inventory. To date RCAHMS has created metadata and released a WMS for its Canmore record, aligned with the Annex I Protected Sites theme, as part of its contribution to the Scottish SDI, from where the information *may* be harvested by UK Location, a UK pan-government initiative established to improve the sharing and re-use of public sector location information including implementation of the INSPIRE Directive. Within the context of INSPIRE questions remain, however, over the purpose of records relating to the wider historic environment beyond those sites that are designated through the Protected Site theme at a UK level.

In Ireland the Department of Heritage, Environment & Local Government (DoHELG) were until recently the main driving body for the development of SDI services within the cultural heritage sector. Several datasets which correspond to the legislation of the National Monuments Act (2004) are available for discovery through the Irish Spatial Data Exchange service (http://www.isde.ie [accessed 12 February 2012]) provided by the Irish Marine Institute. In addition three national monument web services: preservation orders, monuments in state care and the register of historic monuments are available, currently only as bulk downloads from the Archaeological Survey of Ireland's website (http://www.archaeology.ie [accessed 12 February 2012]). However, from late 2011 the DoHELG will utilise

the Ordnance Survey Ireland (OSi) MapGenie. Two further cultural heritage datasets are also available via government websites: National Inventory of Architectural Heritage (available as data download) and the Shipwreck Inventory of Ireland. However this data even though it has been flagged as being available for consultation can only be accessed by appointment.

A recent report on GIS guidance in England by the Association of Local Government Archaeological Officers (ALGAO 2010), whilst acknowledging that INSPIRE establishes the framework for agreed standards and sharing of non-statutory datasets, considered that the directive is only mandatory for statutory protected sites and core reference geographies (ALGAO 2010). This is also the view adopted by the thematic group advising UK Location.

This interpretation is reasonable in providing an argument for prioritising the publication of designated datasets but, at the same time, it removes any incentive for hard-pressed organisations to voluntarily publish complementary datasets. It also implies that information relating to the wider historic environment and cultural heritage does not contribute significantly to policies and activities that may impact on the environment. Clearly there are inconsistencies and nuances in the interpretation of what comprises a Protected Site as many sites are managed through other effective means beyond designation and protection. In fact, this seems to be a rather narrow interpretation of the Data Specification from the INSPIRE Thematic Working Group Protected sites (2010) which defines a Protected Site as an:

> 'Area designated or managed within a framework of international, Community and Member States' legislation to achieve specific conservation objectives' [Directive 2007/2/EC]. According to the International Union for the Conservation of Nature (IUCN) a Protected Site is an area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal *or other effective* [our emphasis] means. Within the INSPIRE context, Protected Sites may be located in terrestrial, aquatic and/or marine environments, and may be under either public or private ownership. They may include localities with protection targets defined by different sectors and based on different objectives. Objectives for protection may include: the conservation of nature; the protection and maintenance of biological diversity and of natural resources and the protection of person-made objects including buildings, prehistoric and historic archaeological sites, other cultural objects, or sites with specific geological, hydrogeological or geomorphological

> value. Protected Sites *may* [our emphasis] receive protection status.'

This definition of a Protected Site is therefore not restricted to legally protected assets but includes those sites which may receive protection status and can be managed through legal or other effective means. The arguments for taking a holistic approach are explored below.

2.1. European Union and International Sector Policies

The definition of Protected Sites, reported above, also specifies a number of European Directives and Conventions, and includes sites covered by the national laws of each European country and EU and international sector policies, suggesting that a much more inclusive approach should be adopted. Through international sector policies, signatory states to the Council of Europe's Granada Convention for the Protection of the Architectural Heritage (1985) and the Valetta Convention for the Protection of the Archaeological Heritage (1992) are required to manage information about their heritage through inventories - a role fulfilled in Scotland through the RCAHMS Canmore database. Environmental information regulations also place emphasis on openness and access to information about the environment. Under The Environmental Information (Scotland) Regulations (2004) every Scottish public authority has a duty to make environmental information available on request. Provision of information about cultural heritage through the Scottish SDI and INSPIRE helps deliver that information.

Access to spatial information about the cultural heritage of a nation is also essential in support of a number of other European conventions. The Council of Europe's European Landscape Convention, also known as the Florence Convention (2000), recognises that 'the quality and diversity of European landscapes constitute a common resource, and that it is important to co-operate towards its protection, management and planning'. The convention requires signatory states to identify and assess, conserve and maintain the significant or characteristic features of a landscape, justified by its heritage value derived from its natural configuration and/or from human activity'. To this end, access to information about the archaeological and built heritage is essential in recognising and defining significant landscapes. However, in some cases, as in Scotland, where RCAHMS is undertaking a national historic land use assessment exercise in partnership with Historic Scotland (http://hla.rcahms.gov.uk/), access to information is less of an issue as the same agencies may maintain both monument and landscape records. Whereas it is argued in this paper that information about individual monuments and buildings should be considered as part of the Annex I Protected Sites theme, Historic Landscape and Land Use characterisation projects complement the Annex III Land use theme.

Access to information about the archaeological and built heritage is also integral to other international policies. For instance, the European Commission policy 'Europe, the world's No 1 tourist destination – a new political framework for tourism in Europe' (2010) whilst encouraging the prosperity of Europe through tourism also recognises the threats of mass tourism to the cultural heritage. The policy encourages diversification of the supply of tourist services using transnational synergies to promote and provide a higher profile for tourism, including cultural and industrial heritage and maritime and sub-aquatic culture heritage. To deliver such ambitions requires easy, and preferably, open access to the information that defines and documents that heritage.

2.2. Informing the Designation Process

Information in national inventories is holistic, recording information on both undesignated and protected sites. For instance, Canmore holds descriptive accounts and related archives that complement the assets designated and protected through Historic Scotland. Information held in Canmore, and related datasets maintained on behalf of Scottish local authorities, may be used in consideration during the designation process. That is, information about the wider historic environment is integral to the decision making processes and formal management of the cultural heritage through statutory procedures.

2.3. Other Effective Means: Planning Guidance

While information about the wider historic environment is important to inform designation, it is essential as a material consideration in mitigation of development proposals. Article 5 of the Valetta Convention (1992) requires the protection and recording of archaeology during development and this is implemented in Britain through planning policy and guidance. Most commercial fieldwork is undertaken as a result of a range of planning guidance and instruction from local authority services. That is, recording of the wider archaeological resource is achieved through *other effective means*.

Scottish Planning Policy (The Scottish Government 2010) recognises the wealth of archaeological sites, monuments and areas of historical interest that do not have statutory designation, and these form an important part of Scotland's heritage. It states that Government policy is to protect and preserve these resources wherever feasible. Planning authorities should consider the potential to protect these resources through the planning process, including using them in development plans to inform planning decisions. For each local authority, local planning policies should also give protection to archaeological sites via preservation *in situ* as the first option.

2.4. Expectation and Best Practice

INSPIRE defines the minimum requirements for sharing information across the public sector. However, expectations for the Scottish Spatial Data Infrastructure in the context of delivering Shared Services across central and local government encompass a far greater range and depth of data than defined by INSPIRE. As more and more information provision moves towards Web Map Services (WMS) and Web Feature Services (WFS), expectations for access to all datasets relevant to the management of the environment will rise. Indeed initiatives such as data.gov.uk complement INSPIRE in encouraging greater transparency across Government, to deliver better value and to realise significant economic benefits by enabling businesses and non-profit organisations to build innovative applications and websites using public data.

2.5. The Research Community

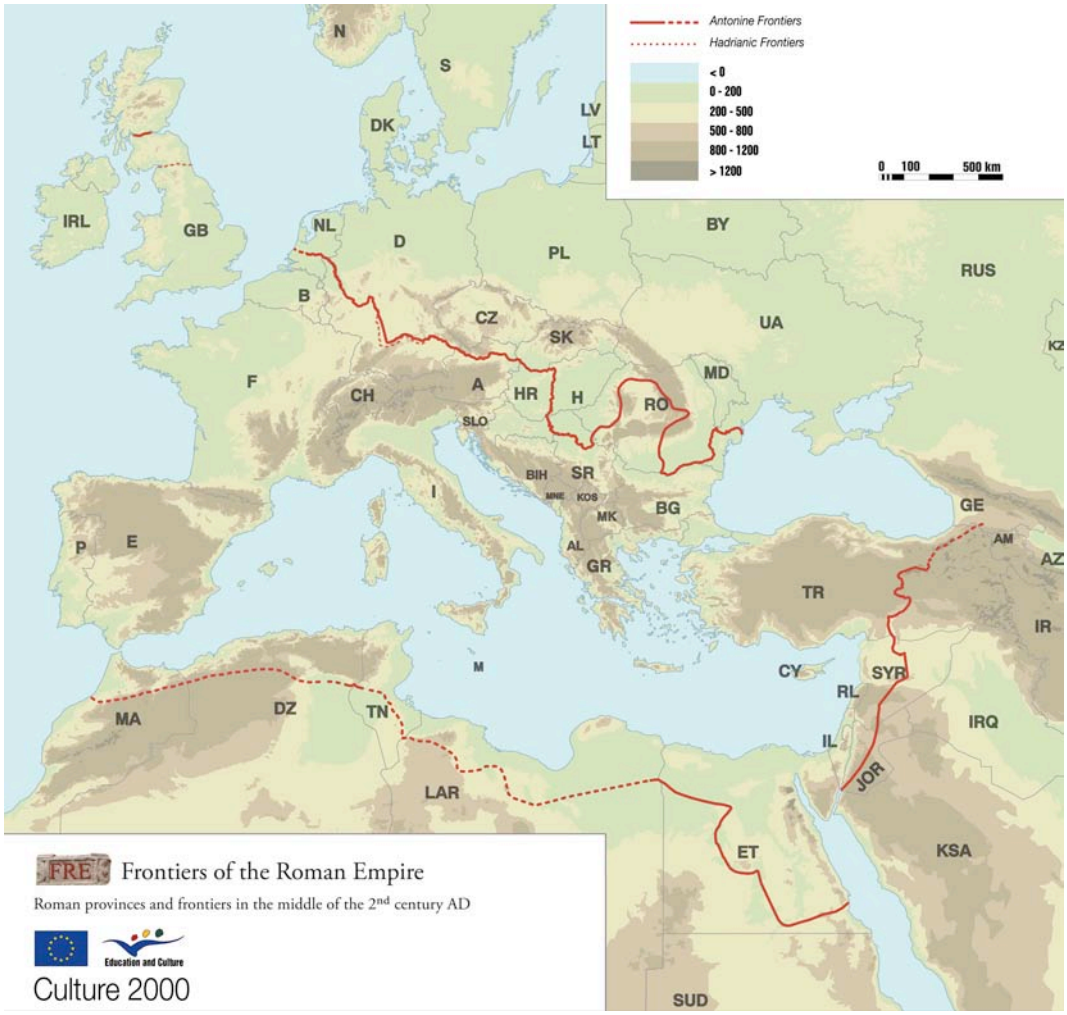
The cultural heritage of Europe shows scant respect for modern political boundaries. For instance, the Neolithic Linearbandkeramik culture, defined by distinctive pottery and building types, stretched over much of central and north-western Europe whilst traces of the Early Bronze Age Únětice culture may be found across much of the Czech Republic, Western Poland and Southern Germany. Archaeology is the study of societies such as these - of how they lived, died, traded and interacted – through traces of architecture, artefacts and related scientific disciplines such as palynology. Research into, and understanding of a shared heritage can be advanced through initiatives such as INSPIRE to harmonise information.

Whilst research may often be restricted to a particular region or district an overview of the broader distribution is necessary to properly understand the context of a site or artefact. Occasionally ambitious multi-national research projects are undertaken across national boundaries. In 2000 an ambitious project undertook research into the introduction of early agriculture across Europe from 9000 BP (Before Present) to 5000 BP, or from the later Mesolithic in South East Europe to the earliest Neolithic in North West Europe through the spatial analysis of radiocarbon dates (Steele et al 2000). In retrospect the scale of the project was underestimated as the state of electronic archiving (and even easily available paper archiving), at the time, for radiocarbon dating evidence relating to European prehistory was generally very poor with one or two notable exceptions.

At its height the Roman Empire stretched from Scotland in the north west of Europe to countries surrounding the Mediterranean Sea and as far east as the Caucasus (Figure 1). The Empire shared common cultural traits with local influences, reflected in the monumentality of Empire. Work is ongoing to recognise the Roman frontiers across much of Europe as part of the UNESCO transnational property ‘Frontiers of the Roman Empire’, building on the Inscription

of the German Limes, the Antonine Wall and Hadrian's Wall in the United Kingdom. Each nomination was supported by interpretation and management plans supported by detailed records of the locations of the frontiers.

Figure 1: The Roman Empire: - a Common Cultural Heritage



Access to spatial information is equally relevant for the study of the built environment. For instance through their Digitising Heritage project (http://www.historic-scotland.gov.uk/index/heritage/historicandlistedbuildings/digitisingheritage.htm [accessed 12 February 2012]) Historic Scotland are developing a multi-

disciplinary team including representatives from RCAHMS, the Norwegian Museum of Hydropower and Industry and The International Committee for the Conservation of the Industrial Heritage (TICCIH) to create an online toolkit for the creation of individual web-sites across specific themes, such as industrial heritage. The initial project will explore the technology of hydro-electric power; the Dams, Power Stations and water-systems used to generate green energy.

2.6. The Counter Arguments

Inevitably greater access to information does pose a threat to the cultural heritage resource through theft and, for the archaeological resource, illegal metal detecting or 'night-hawking' in particular. Some information is considered sensitive and is withheld for this reason, but in a mature society it is in the interests of the historic environment that information is visible and consulted alongside other considerations rather than shielded from the public, who, by and large, have funded most of its collection. Restricting information runs counter to novel ways of encouraging the public to appreciate their heritage through participatory approaches to both national and local inventories (for instance Lincolnshire heritage at risk http://www.lincshar.org/ [accessed 12 February 2012]).

Information about the wider historic environment is often difficult to use without advice, with records often being poorly defined both quantitatively and spatially. Unlike statutorily defined datasets which represent a finite number of defined assets, the totality of the wider cultural heritage is unknown, particularly in upland areas, with new discoveries revealed through fieldwork, often initiated as part of an Environmental Impact Assessment or a planning condition. Whereas statutory designations are generally rigorously defined spatially through the designation processes, information about the wider historic environment may not be. Records are often represented by a point co-ordinate rather than a defined extent. There are genuine concerns that the complexity of this record may be misunderstood if accessed remotely without appropriate advice and mediation as well as weakening mitigation of applications submitted through the planning process. Yet, to remain relevant, cultural heritage managers need to fully engage in both their local Spatial Data Infrastructures and INSPIRE to promote their resources to ensure that cultural heritage remains prominent and relevant in the knowledge economy of the 21st century.

2.7. Contributing to the Economy

The historic environment makes a significant contribution to both the financial and cultural wealth of a nation. In 2010, the historic environment contributed in excess of £2.3 billion to, or 2.6% of, Scotland's national gross value added (GVA). In Ireland for the same period the total economic impact of the historic environment contributed € 1.2 billion to the national income (4.3% of GVA)

(Whitfield 2011). The historic environment directly supports more than 41,000 full time equivalent employees in Scotland and after considering indirect and induced effects, the sector supports in excess of 60,000 full time equivalent employees, accounting for 2.5% of Scotland's total employment (Historic Scotland 2010). Much of this work is underpinned by access to information; as part of the planning process and in Environmental Impact Assessments; or in conservation and restoration projects and in the wider appreciation of a nation's cultural wealth through leisure and tourism.

2.8. Taking a Voluntary Approach

UK Location recognises that if a dataset does not appear to come under an INSPIRE theme, this does not stop the publication of it, it just removes the obligation to do so (UK Location 2010). At the moment there is arguably no obligation to publish datasets beyond the current narrow view of 'Protected Sites' as designated assets. Yet it is essential for effective stewardship of the cultural heritage that a broader interpretation of 'Protected Sites' is favoured for the implementation of policies and management of a fragile environmental resource. As argued above, information about the archaeological and built heritage is utilised by a range of audiences actively engaged in the management of the historic environment as well as informing the agri-environment sector, Environmental Impact Assessments, development control process and stimulating research and interest in the heritage. At the same time careful and considered stewardship of the historic environment helps preserve its character for both the present and future generations to appreciate, and stimulates interest in cultural heritage through recreation and tourism. Easy access to spatial information that identifies and defines that resource is therefore essential.

3. ENRICHING CULTURAL HERITAGE RESOURCES

The Convention on the Protection of the Archaeological Heritage of Europe 1992, (the Valetta Convention) requires that member states of the Council of Europe and the other States party to the European Cultural convention maintain an inventory of a state's archaeological heritage, integrate archaeological fieldwork into the planning process, collect and disseminate scientific information and promote public awareness. The range of information gathered in the investigation of the cultural heritage by publicly funded agencies and through commercial organisations, research institutions and community groups contributes to our understanding of the historic environment and its preservation and appreciation.

Sophisticated survey and mapping techniques are increasingly used in prospective survey, generating datasets of interest beyond their immediate purpose. Yet once each project has been completed and published, the underlying datasets are usually stored in project silos with limited mechanisms for

discovery, view, download or re-use in place. The development of national Spatial Data Infrastructures serves as a model for unlocking the rich potential of these datasets so that information is gathered once, and used often. However, the ability to realise the full potential of cultural heritage data through re-use and sharing with external organisations and the wider research community is limited by technological, semantic and organisational barriers. Capturing and processing primary spatial data is expensive and any failure to fully exploit the investment in such cultural heritage data could result in reluctance to commission future projects. The range of information created through archaeological investigation is explored through the following case studies.

3.1. The Work of the Royal Commission on the Ancient and Historical Monuments of Scotland

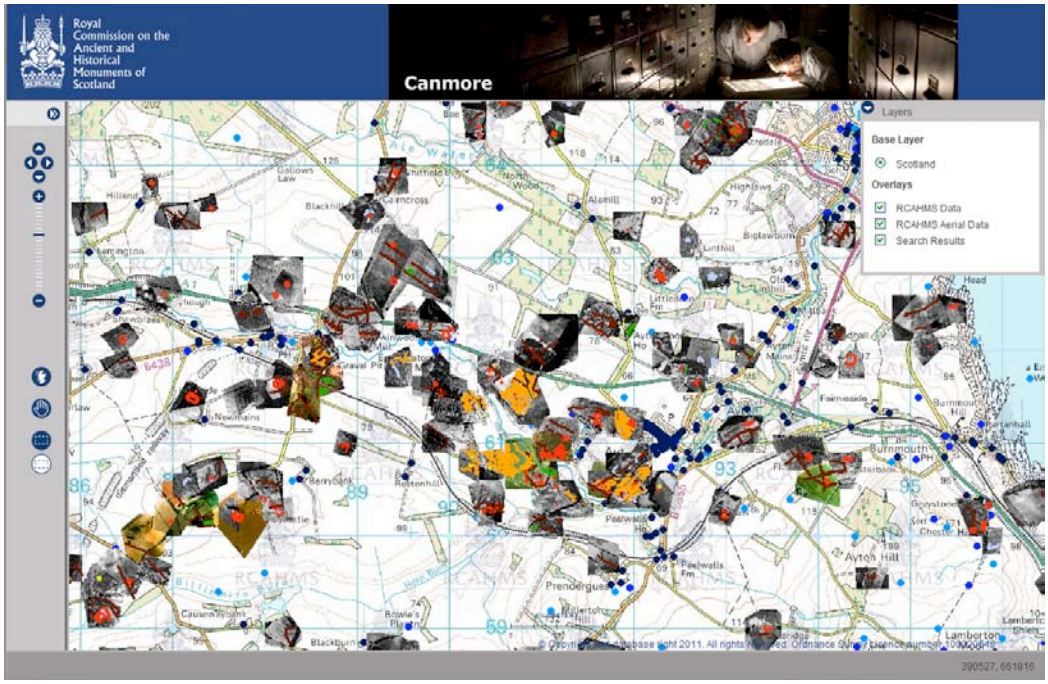
The requirement for a national inventory of archaeological sites, set out in the Valetta Convention, is primarily met in Scotland by RCAHMS who maintain an integrated inventory of Scotland's heritage. This combines both the inventorial and archival processes in a single relational database accessible online through Canmore (McKeague et al 2008).

Content in the national inventory grows through the annual reporting of fieldwork from commercial organisations, research institutions, community groups, through RCAHMS own fieldwork and aerial reconnaissance programmes, and data exchange with local authority services. RCAHMS own field survey projects identify, record, map and interpret the archaeological and architectural resource. The spatial information recorded includes the extents of survey areas, and may include detailed mapping of sites and landscapes. Similarly RCAHMS aerial reconnaissance and interpretation identify and photograph plough truncated sites and landscapes revealed through differential crop growth that would otherwise be invisible to archaeologists. Using transcription software and the skills of the aerial photograph interpreter, the cropmark landscape is being mapped systematically at 1:2,500 scale.

Following guidelines produced by the Scottish Government (Duffy 2010), RCAHMS released its first WMS in May 2010 (available through (http://scotgovsdi.edina.ac.uk/srv/en/main.home/ [accessed 12 February 2012]). The published WMS provides the user with a spatial view of the site location information from Canmore, and it complements the statutory datasets released by Historic Scotland as part of the Annex I Protected Sites theme. The WMS is consumed in the mapping component of the Canmore website and published on the Scottish Spatial Data Infrastructure portal. Through the WMS the user can identify individual features in the map and see limited associated information, such as the record number, the site name and classification as well as the web address of the full record on Canmore.

Publishing location information helps users find a site or building of interest. However, the inclusion of a 'site' in Canmore (or any other record system) is dependent on the activities or techniques that investigate, reveal or identify cultural significance. For instance many archaeological sites under arable crop are revealed through cropmarking where variations in buried archaeological features retain or lose water resulting in differential crop growth. In early 2012 RCAHMS will publish a WMS for its Aerial Photographic Survey Mapping Programme in the Scottish Spatial Data Infrastructure Portal. Formerly the transcription information was only easily accessible to staff at RCAHMS through their desktop GIS or as part of the associated Collections and, as such, the data was not regularly consulted by either the public, or by professional archaeologists undertaking desk-based assessments or fieldwork under contract.

Figure 2: Aerial Survey Mapping Programme WMS consumed by the Canmore Mapping Application Portal

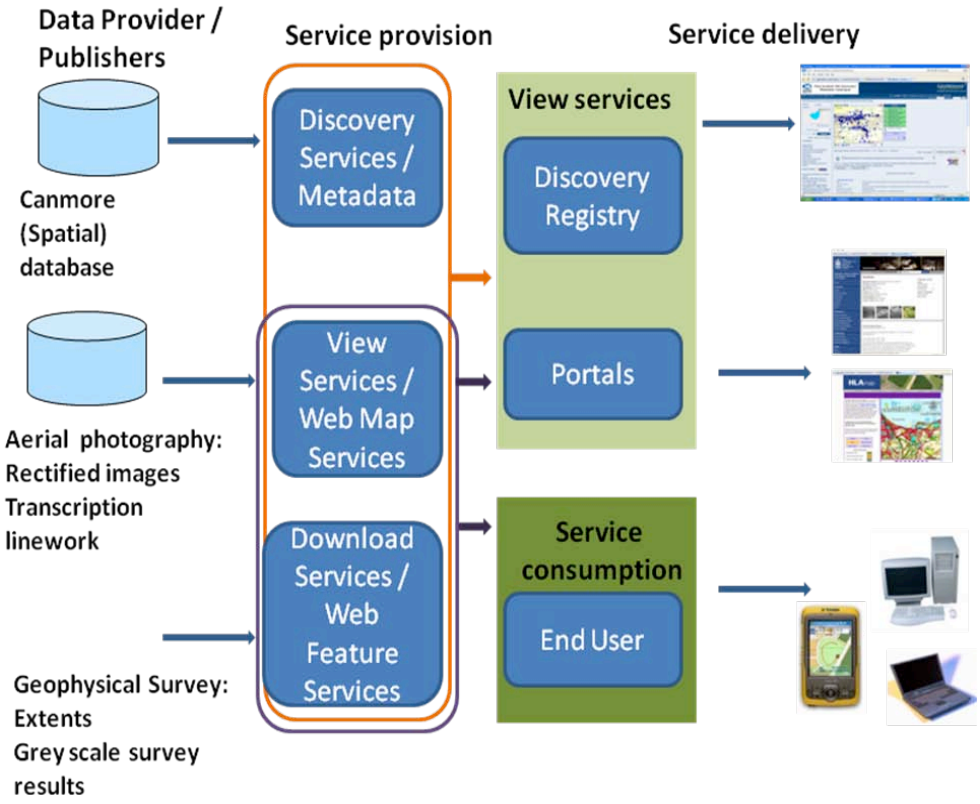


Source: Base mapping © Crown Copyright and database right 2011. All rights reserved. Ordnance Survey Licence number 100020548

Publication of the aerial survey mapping as WMS allows both the interpreted transcriptions and geo-rectified digital copies of the original oblique photography at screen resolution, to be published on Canmore (Figure 2) and shared with

professional users ensuring it is used much more effectively in planning and other assessments (Figure 3).

Figure 3: Meeting Multiple Audiences through Web Map and Web Feature Services



To date RCAHMS has only produced WMS for data that it is directly responsible for creating. However, there is also a wealth of spatial information generated through third party fieldwork, deposited with RCAHMS as part of project archives, which could be shared through hosted services. In Scotland (and England) most commercial archaeologists use an online application, OASIS (Online Access to the Index of archaeological investigations) hosted by the Archaeology Data Service (ADS), University of York (Hardman et al 2003), to systematically report project metadata to local and national curators. Currently, the ADS, English Heritage and RCAHMS are investigating the use of the Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH) to provide metadata for marine projects reported through OASIS to the Marine Environmental Data Information Network (MEDIN) portal (http://www.oceannet.org/ [accessed 12 February 2012]), including links back to the relevant record in Canmore. In time, information gathered through OASIS could also be provided as WMS and WFS

although mostly as point data rather than reflecting the extents of investigation. At RCAHMS, the potential is currently under consideration for developing collaborative, hosted services for geophysical and remote sensing surveys where RCAHMS would provide the infrastructure to host the requisite services for the range of onshore and offshore surveys. A similar approach could be considered to document and signpost the increasing numbers of laser scan surveys undertaken of historic buildings and archaeological monuments.

Figure 4: Combining Information from a Variety of Techniques to Understand the Roman Fort and Frontier Defence at Balmuildy, Lanarkshire

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The range of information described above was brought together to support the nomination documents for the successful Inscription of the Antonine Wall to the transnational Frontiers of the Roman Empire UNESCO World Heritage Site in 2008.

As part of the preparatory work RCAHMS collated information from a variety of mainly non-digital sources to build up a detailed picture of the investigative history along the frontier. Research combined information from previous surveys by the former Archaeology Division of the Ordnance Survey, fieldwork and aerial reconnaissance and interpretation by RCAHMS, with evidence from excavation and freshly commissioned geophysical survey. This provided a powerful tool for the management, protection, conservation and interpretation of a complex archaeological landscape (Figure 4).

In the mantra of One Scotland, One Geography (The Scottish Government 2005), RCAHMS seeks to 'ensure access to the most up-to-date and accurate geographic information about Scotland that can be delivered with the best use of resources'. Through the promotion of INSPIRE to professional colleagues, publishing its own services and developing hosted services for information created by the wider archaeological community, RCAHMS aspires to encourage and support the wider archaeological community in Scotland to think and work spatially, to make best value of limited resources.

3.2. The Discovery Programme

Within Ireland, the Discovery Programme has promoted the adoption of the INSPIRE Directive within the wider cultural heritage community. Since 2008, the Discovery Programme has researched the potential for the discovery and reuse of archaeological remote sensed data within the wider research community and beyond utilizing SDI (Corns et al 2008).

Over the past 15 years much financial and professional effort has been invested in the collection and analysis of spatial archaeological data by government, research and commercial sectors within Ireland. Within this digital domain asset, landscape data forms a substantial component and includes: aerial photography; topographic surveys created by Lidar (Light Detection and Ranging) and digital photogrammetry; and geophysical surveys. Extensive aerial survey and Lidar surveys have been carried out by numerous governmental and research bodies including The Discovery Programme, The Heritage Council, University College Dublin, NUI Galway, Department of Environment, Heritage & Local Government (DoEHLG), and Meath County Council. In 2007 alone, 264 detection licenses were issued by the DoHELG of which the majority would be used for the primary collection of geophysical data sets.

Once this data is recorded and interpreted, the printed report is often seen as the final deliverable, while the digital archaeological assets created often remain hidden and unused within the source organisations, eliminating any possible knowledge transfer to the wider archaeological community. In the current economic climate the possibility for the loss of archaeological information is great

as the digital data collected and held by commercial companies could potentially disappear (MacConnell, 2011).

Several reports (Royal Irish Academy 2006, The Heritage Council 2006, 2007, University College Dublin 2006) reviewing the current archaeological research framework within Ireland highlighted concerns that exist within the archaeological community that require further action. Following the completion of a Heritage Council funded landscape project (Lambrick, 2008) it was noted that a review examining the long term prognosis of the information derived from data projects should be commissioned, with the possibility of creating a centralized geodata server. Specific concerns were also highlighted in an open letter to the Heritage Council, by the Royal Irish Academy expressing the opinion that 'an online guide to air photographic collections' should be a practical priority for the Heritage Council.

Major problems to the successful development of the knowledge society in Irish archaeology include:

- Underdeveloped and poorly resourced research infrastructure.
- The unconnected nature of archaeological information and key resources within the archaeological research community
- A lack of accessible and sustainable digital archives for archaeological data, with established standards and metadata
- An inadequate return on the investment in primary data collection, from both development led and grant funded archaeological practice, resulting in the production of hidden archaeological material

The solution for many of the highlighted problems is the creation of an effective complementary ICT strategy which provides easy access to primary research information whilst providing a sustainable and robust digital archive that adheres to recognized international standards. Developments in Geographical Information Systems (GIS) have provided researchers with new mechanisms to access improved archaeological data sets. The tools within GIS enable the visualization, cataloguing and analysis of a varying scale of spatial data improving the investigative capacity of the researcher. Creating a coherent infrastructure where high quality landscape data is easily accessible will maximize the knowledge return from this resource and enhance future archaeological research.

The Discovery Programme, in common with many organisations involved in archaeological research or cultural heritage management is generating increasing volumes of high quality spatial datasets in the course of its research projects. It is now commonplace to carry out geophysical surveys, generate orthoimagery (1:7,500 scale photography approximately 0.16m resolution) and DEM's from photogrammetry (0.5m resolution), or commission high resolution

Lidar surveys (0.12m resolution), all rich resources which are used to further our understanding of the archaeological record (Figure 5).

In many cases funding for this data collection comes – directly or indirectly – from public sources, through national or EU funding, but with no requirement or mechanism to make the collected datasets available to other potential users. Once research has been completed and published, the underlying spatial datasets often remain hidden from, and unavailable to, the wider research community, thus failing to realize their full potential.

Figure 5: Example of High Resolution Orthoimagery and Lidar Data for the Hill of Tara Archaeological Complex (County Meath, Ireland), currently a tentative UNESCO site

A group of like-minded archaeological researchers in Ireland recognized this problem and expressed the common desire to open up and share the resources they independently held. In 2008, through an Irish National Strategic Archaeological Research (INSTAR) grant, a feasibility study was undertaken, coordinated by the Discovery Programme to examine the mechanisms and technologies which would allow the sharing and re-use of our spatial landscape data by the wider community. Called the Spatial Heritage & Archaeological Research Environment I.T. (SHARE IT) project (Corns et al, 2008) this one year study examined many of the issues related to archiving, accessing and sharing data, and concluded that Spatial Data Infrastructures (SDI), specifically for archaeological and heritage landscape data would provide a possible solution.

Within the SHARE-IT project several OGC compliant services where established in a test capacity to assess the feasibility of serving out a wide range of archaeological geospatial data sets to as wide an audience as possible (Figure 6).

Geophysics WCS: Traditionally the results of geophysical surveys are presented to experts and the wider community as static images (e.g. Tiff/Jpeg Images) which in some instance have been geo-referenced. However, this abstraction of data into a visual form divorces it from the underlying source data. By providing the geophysical dataset as a WCS the user can still visualise the data to identify any potential geophysical anomaly and if required they can interrogate the data for specific cell values. Survey extents would on average be 0.25km^2 with a ground resolution of 0.25cm

Lidar DTM WCS: Similarly to the geophysical data expert users may require access to the underlying values within a Lidar dataset to generate dynamic topographic sectioning or the ability to generate different visualisations to enable the identification of archaeological features (Hesse 2010). By providing Lidar data as a WCS the user has the ability to carry out such actions. Lidar datasets vary in scale and resolution ranging from fixed wing surveys (approximate survey extents of 100km^2 with an effective ground resolution of 1.0-0.5 m) to high resolution surveys carried out by helicopter mounted Lidar sensors (approximate survey extents of 4km^2 with an effective ground resolution of 0.2-0.1m

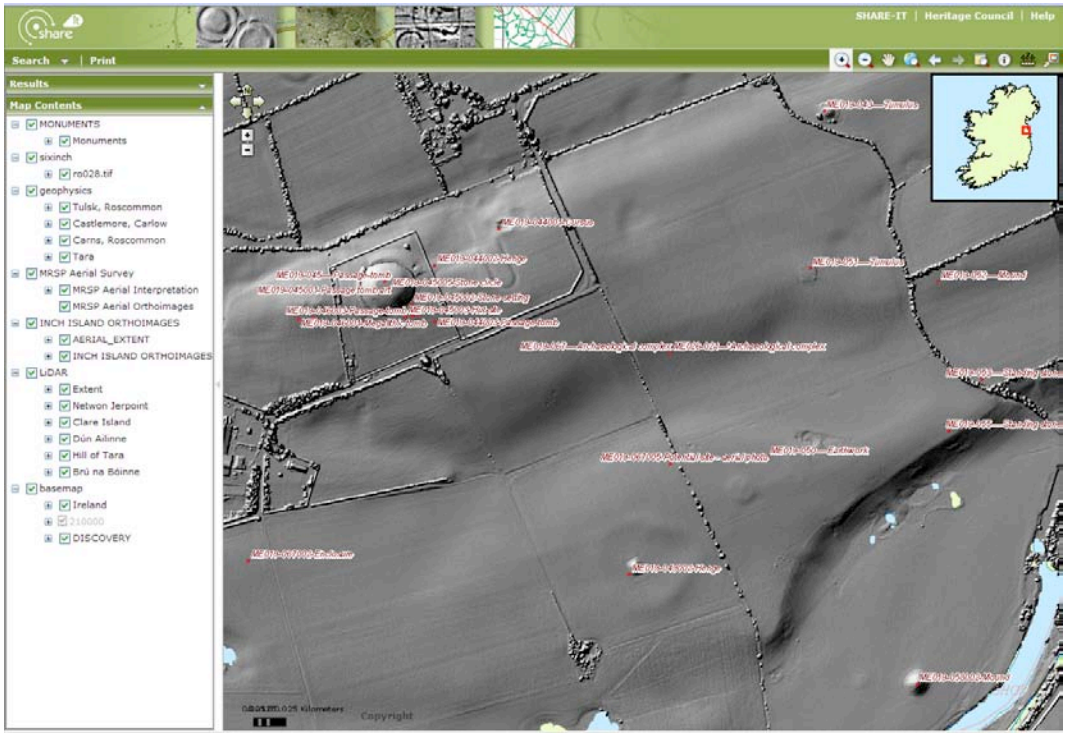
Lidar shaded relief WMS: For those archaeological experts requiring a simple hill-shade model visualisation of Lidar topography a WMS service is provided, an invaluable data sets for the archaeological prospection across the wider landscape. The resolution and scale of these services matches those from the original source DTM.

Orthophoto WMS: In addition to many WMS providing background imagery, the archaeological community commissions many targeted aerial surveys which

provide archaeological monument and landscape data at very high resolutions or is captured at times of the day/year which are not considered optimal for conventional vertical photography. The resolution of the imagery would normally be 16cm however the extent of the survey ranges considerably depending upon the initial capture specification (example extents can range from 20-200km^2)

Survey Extents WFS: Polygon web feature service outlining survey extents for geophysical, Lidar, orthoimagery and other remote sensing data sets. This data set acts as an initial guide to the user on the availability of datasets for their required study area. All polygons were linked to the appropriate documentation outlining the results and possible archaeological interpretation of the survey, and where applicable a hyperlink to the appropriate WCS or WMS.

Figure 6: Screen Shot of the SHARE-IT Web Mapping Application Displaying Lidar Hill-shaded WMS and National Monument WFS for the Brú na Bóinne UNESCO World Heritage Site

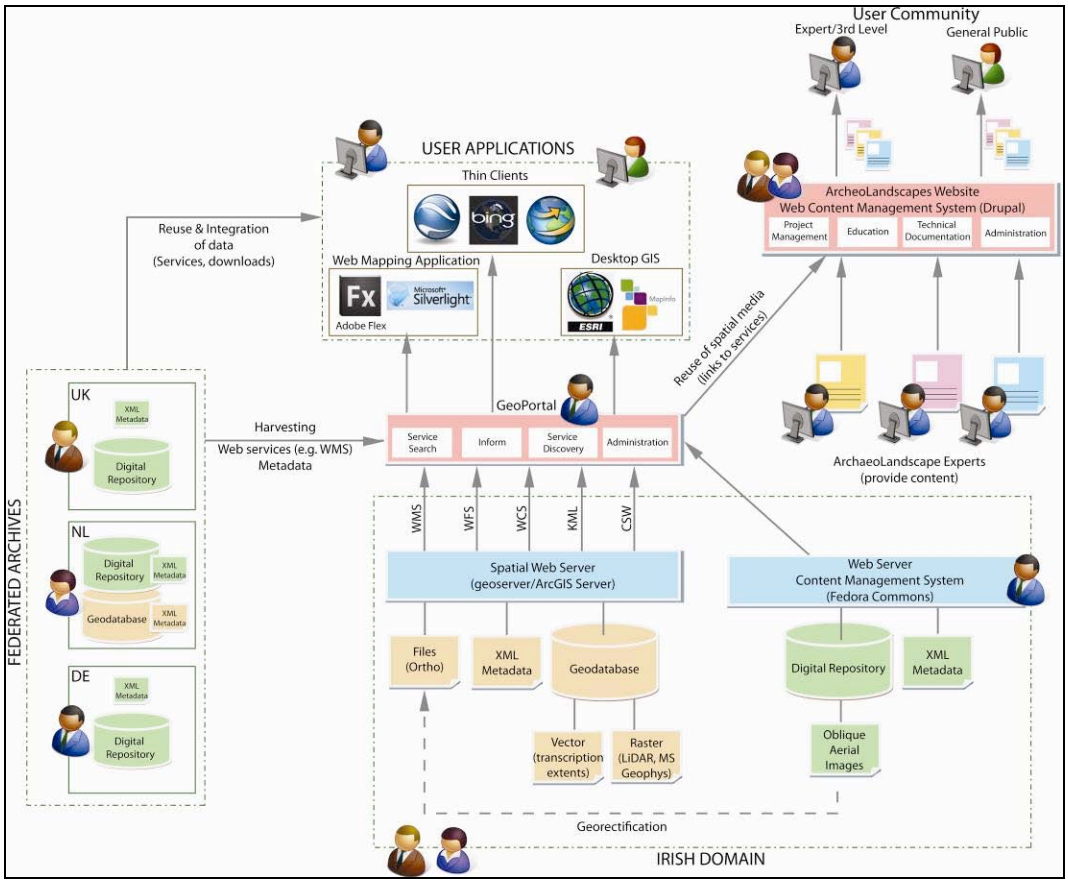


In addition to the development of the OGC compliant web services, a simple web mapping application was constructed to enable those without access to traditional desktop GIS to consume the services in an environment tailored for the archaeological research community

3.3. Archaeolandscapes Europe SDI

In addition, both the RCAHMS and The Discovery Programme are coordinating efforts within a new EU Culture 2007 - 2013 funded project Archaeolandscapes Europe (ArcLand). The target of the ArcLand project is to address existing imbalances in the use of modern surveying and remote sensing techniques to create conditions for the regular use of these strikingly successful techniques across the Continent as a whole. It aims to create a self-sustaining network to support the use throughout Europe of aerial survey and 'remote sensing' to promote understanding, conservation and public enjoyment of the shared landscape and archaeological heritage of the countries of the European Union.

Figure 7: Schematic Diagram of the Components and Interactions of the Proposed ArcLand SDI



Within these wider objectives of the project the aim is to construct a system for the delivery of aerial archaeology and remote-sensing data to the general public, and to educational and academic research communities. In preparation for this

objective a SDI model has been generated to identify the major components and how they will interact (Figure 7).

Within the ArcLand SDI several components can be identified:

Data archive/Geoserver

The SHARE-IT project highlighted the importance of creating an archive for spatial data conforming to the best international practice. For the ArcLand project two digital data repositories are proposed, one to deal with the truly spatial datasets, such as orthoimagery, Lidar and geophysical data, and another to deal with the non-spatial data such as non-rectified oblique aerial photography. The project will assess both open source and proprietary software solutions, documenting the processes to enable other partners to establish their own geospatial archives.

The Fedora Commons open archive model is seen as the best solution to the storage and access of the non-spatial datasets and associated metadata. Research is planned into the potential to migrate these datasets into spatial data through geo-rectification.

Geoportal

This is the vital component within the system, the development of a single website which acts as the hub for the user's spatial requirements, providing the tools to search, discover, access and consume spatial data. One of the great strengths of the geoportal is its ability to harvest metadata records from remote archives, such as those of the ArcLand partners, and construct a metadata catalogue. The result would be a geoportal providing a single access point for European archaeological spatial data. This widening of access to data will inevitably raise important and legitimate concerns over the issue of access management and copyright control but this could be dealt with through the implementation of the Creative Commons.

User applications

Using web services as the delivery mechanism for spatial datasets has the significant advantage that they can be consumed by a range of devices and software applications providing a user experience appropriate to the consumer's requirement.

- Thin-client web applications such as Google Earth or Microsoft Bing Maps provide a software environment which is both free and familiar to a rapidly growing section of the public

- Alternatively, the more experienced GI user can consume datasets via web services from remote servers to their standard desktop GIS system such as ArcGIS. The advantages of this are that the user retains access to their full suite of processing and analysis tools, and accesses data of reliable quality and currency without storing a copy of the data locally.
- Another increasingly common approach is to custom design a tailored web mapping application. The development of software such as Adobe Flex and Microsoft Silverlight provides a simple, fast way to develop what are known as rich internet applications. These web applications, with GIS functionality, place an emphasis on the quality of content and have the potential to significantly increase the user community. In the case of ArcLand this would provide the tools to promote cultural heritage data effectively to a broader community and thus generate huge educational benefits - both core objectives of the project.

Content integration

An important component of the ArcLand project is the creation of other non-spatial content such as supporting documentation and media that will improve the understanding and awareness of the primary spatial datasets and the technologies used. Integrating this content into the system via a Joomla! content management system (CMS) presents the user with a more complete and seamless user experience. An example of this could be the integration of teaching material prepared by a partner organisation being linked to appropriate live spatial datasets to create an integrated lesson which students around Europe could access and use at their desktop

4. CONCLUSIONS

The historic environment of Europe is a finite and fragile resource. It is managed through a combination of statutory and other effective means to ensure that future generations can appreciate and be inspired by the cultural heritage that surrounds us and has shaped the environment we live in. Although INSPIRE aims to deliver a common infrastructure for information to support environmental policies and activities, the legal framework for implementation rests on a very narrow definition of 'Protected Sites' as only those sites afforded legal protection. The Annex I Protected Sites theme ensures that key spatial information about designated sites is published in accordance with the timetable set out by the INSPIRE Directive. However, these sites represent a small fraction of the wider historic environment that, although afforded some protection through planning policy and guidance, is under considerably more immediate threat. Although there is currently no compulsion to provide access to information about the wider historic environment, access to core reference data is essential for the stewardship of the cultural heritage. If it is not obligatory to publish non-statutory

information through INSPIRE and local implementations of SDIs, those organisations responsible for maintaining records about the historic environment ought to adopt and possibly extend INSPIRE as best practice to ensure the information they are responsible for is accessible alongside statutory information released as part of Annex I Protected Sites.

Investigation of the historic environment adds richness and depth to the records that define the cultural heritage. Datasets such as the Lidar surveys and other remote sensing techniques are covered by and indeed span Annex II themes including Elevation, Land cover and Ortho-imagery and have transferable value to other agencies and disciplines. However, the locations of detailed investigations including archaeological mapping of cropmarks, the position of excavation trenches, or standing building recording do not easily map to INSPIRE themes. This is the information that provides the evidence for and helps define an archaeological site or historic building. It is, therefore, essential documentation that helps inform further research, or consideration of the significance of that heritage. Much of this information is born digitally and has a value beyond its immediate purpose, however once the project has been completed and its results published, these spatial datasets often languish forgotten and inaccessible with the data creator. The potential to reuse and inform future work is therefore compromised. Although most research institutions and commercial organisations are not required to comply with the INSPIRE Directive, the standards and mechanisms INSPIRE promotes offer the potential to develop sustainable resources that unlock the archives and deliver efficiencies in the future. Yet much of this information is created by third parties with no obligation to contribute to an SDI dataset. The case studies presented within this paper illustrate the potential of such datasets in documenting and defining heritage. The rich archaeological landscape revealed through the systematic mapping of cropmarks visible from aerial photography (Figure 2) may be combined with the results of excavation (Figure 4) or remote sensing techniques including geophysical survey and Lidar surveys (Figures 4, 5 and 6) to provide the evidence for Europe's shared cultural heritage.

Even though the INSPIRE Directive, national and regional SDIs may have developed without specific reference to the needs of the historic environment, the policies and principles are highly relevant. The standards, procedures, metadata and services required to provide an INSPIRE service are equally applicable for heritage data. However, in contrast to INSPIRE, national and regional SDIs which focus on datasets held by public organisations mandated through legislation to release publically funded data, creation of an SDI for the cultural heritage poses very different challenges. Potential contributors to an SDI for the cultural heritage are drawn from government agencies, academia, research organisations, private consultancies and the wider community. For most, there is neither a legal requirement to publish metadata, WMS and WFS for the data they create nor

even an awareness of the potential an SDI for cultural heritage offers. Even if there is a will or moral obligation to publish, many organisations simply do not have the resources and capabilities to contribute. Without a formal SDI for the cultural heritage, those organisations interested in and capable of publishing their data to industry standards must lead by example. This can be achieved through their own work programmes or as contributors to Archaeolandscapes Europe (ArcLand) and act as coordinating organisations to host and collate services on behalf of partner organisations.

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