CHAPTER 6

GIS APPLICATIONS IN ITALIAN ARCHAEOLOGY. THE RESULTS OF A SURVEY AND THE DEVELOPMENT OF THE *CAERE PROJECT*

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1. INTRODUCTION

This chapter is an attempt to synthesize the main results of a survey on "GIS and Archaeology" promoted and carried out in 1997 by the *Istituto per l'Archeologia Etrusco-Italica* of the Italian National Research Council[1], under the responsibility of Dr. Paola Moscati and the direction of Prof. Mauro Cristofani, prematurely deceased four years ago.

This survey represented the first phase of a project, entitled "*Establishment of an Archaeological Information System model and its application to ancient Cerveteri*" (henceforth "the Caere Project"). It was promoted by the Institute in the framework of the CNR "Cultural Heritage" Special Project[2], whose aim is the safeguard, improvement and fruition of our national cultural patrimony through knowledge, recording, restoration and conservation. The purpose of our project is to use an archaeological information system in the study of the ancient Etruscan town and territory of Caere, where the *Istituto per l'Archeologia Etrusco-Italica*, now directed by Prof. Adriano Maggiani, has been carrying out surveys and excavations since 1982, together with the *Soprintendenza Archeologica per l'Etruria Meridionale* (Cristofani, 1986; 1992; 1993; 1996).

The first step of the Caere Project was the circulation on-line of a questionnaire, in order to gather general information concerning current GIS applications in archaeology, with particular reference to their use in excavations. The goal pursued was not so much to obtain an exhaustive international census of all the research projects, but rather to get as complete a panorama as possible of the topics related to this sector of applications (*i.e.* technical and methodological issues common to many projects and specific trends within the various countries that had joined this initiative).

For this reason, an international Scientific Committee was selected. Its members are among the most distinguished scholars in this field of studies; they have been given the specific task of co-ordinating the initiative within the various geographical areas and of helping to publish the results of our survey. The Committee was co-ordinated by François Djindjian and its members were Daniel Arroyo-Bishop (France), Juan A. Barceló (Spain), Ian Johnson (Australia, New Zealand), Kenneth L. Kvamme (North America), Gary Lock (UK), Torsten Madsen (Scandinavian countries), Zoran Stančič (Eastern Europe), Albertus Voorrips (Holland, Belgium and Central Europe), Tito Orlandi and Paola Moscati (Italy).

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[1] http://soi.cnr.it/~iaei.
[2] http://www.culturalheritage.cnr.it.

All collected information has been published in the ninth issue of the journal *Archeologia e Calcolatori* (Moscati, 1998a), edited by our Institute since 1990[3].

The questionnaire, simple enough in appearance, was compiled with a view to propose synthetically some precise questions regarding different issues. Some of these issues are intrinsic to each project (title, promoting institution and term), but they are also spatial (geographic or excavation areas under study), technical (hardware and software), or methodological (use of descriptive standards, application of Spatial Analysis techniques) character; lastly, they regard data diffusion (web sites). A complete reply to all these questions obviously presumed that the research described was not in a merely planning phase. This allowed us to limit the panorama of our census only to those projects already in course of execution.

This survey led to some interesting methodological considerations, which can be summarised as follows.

- An evident distinction, considering the technical solutions adopted and the aims pursued, between projects carried out in the CRM framework and those established by research institutions.
- An analysis of the GIS approach, considered as a complex methodology, which allows the integration of various computer methods already tested, rather than only as a new technical computer tool.
- An innovative concept of GIS as a model for archaeological data acquisition, representation, structuring and interpretation, especially in the sector of field research.

In the years following the publication of our survey, we have continued to collect information on GIS applications in archaeology, through a systematic bibliographic survey. This further check has allowed us to closely analyse the advancements in this sector of computer applications. Once more they can be summarised as follows.

- A substantial confirmation of computer technologies already adopted, but more attention towards the exchange formats and the implementation of specific routines rather than the mere use of standard algorithms.
- A more complex definition of the term GIS, which is now often connected with other qualifying suffixes, such as Time GIS, Object Oriented GIS, Virtual Reality GIS, that imply both specific requirements of archaeological research and innovative methodological aspects.

2. "GIS AND ARCHAEOLOGY": THE ITALIAN SITUATION

The adoption of GIS in Italian archaeology (Moscati, 1998b) dates back to the end of 1980s, but only during the 1990s has it fully answered the specific demands of archaeologists. Computing archaeological projects in which GIS are used have involved nearly the entire national territory, from Valle d'Aosta to Sicily. The major part of the territories analysed have been chosen as specific archaeological areas with uniform characteristics. Only in a few cases, exploratory excavations within each region have been carried out. Some of the Italian projects also regard archaeological areas outside national limits, like the Iberian territory, Northern Africa, Greece, the Near East and Asia.

[3] http://cisadu2.let.uniroma1.it/iaei.

One of the emerging issues within the results achieved is that in Italy, as in other countries, there is a distinction between projects carried out by institutions dealing with the administration and safeguarding of the national cultural patrimony, usually listed under CRM (Cultural Resource Management), and those carried out by academic and research institutes such as Universities, Academies or other specific centres. This distinction concerns both the methodologies of investigation and the aims pursued. Generally, the CRM sector refers to ministerial institutions and follows administrative purposes while the second sector is aimed at a more analytical study, carried out in general on a more restrictive land scale. Unfortunately, there is often a lack of communication and co-ordination between the two sectors, which would surely be productive from a methodological point of view, and which would, in any event, limit double spending.

2.1. CRM projects

CRM projects in Italy are generally connected to the activities carried out by central and regional offices under the direction of the *Ministero per i Beni e le Attività Culturali*[4] and addressed to the managing, protection, maintenance and fruition of the national cultural patrimony. A framework of reference of computer applications may be gleaned from the activities promoted and carried out by the *Direzione Generale per il Patrimonio Storico, Artistico e Demoantropologico*[5] in cooperation with the *Istituto Centrale per il Catalogo e la Documentazione* (ICCD)[6]. ICCD is an organ of methodological control: its activity pertains to the standardisation of archiving criteria, from the formulation of rules, the normalisation of descriptive language, and the subsequent establishment of thesauri and the publication of terminological dictionaries. ICCD also has the role of developing computer tools in order to operate a formal control on recorded data and to allow easy transfer and on-line access to the data. The use of a GIS platform in this context has the purpose of permitting the localisation of sites and monuments within the national territory, in order to adopt the best technical and methodological solutions in the establishment of a georeferenced information system.

Another project can be considered in the framework of the CRM sector, the "Risk Map of Cultural Heritage", promoted by the *Istituto Centrale per il Restauro* (ICR)[7]. This initiative is aimed at the definition and evaluation of the decay factors of archaeological areas, monuments and works of art and at the managing of all information concerning the conservation of cultural heritage on a national scale. It also involves the analysis of the means to prevent and inhibit the effects of natural or accidental environmental factors.

[4] http://www.beniculturali.it.
[5] http://www.arti.beniculturali.it.
[6] http://www.iccd.beniculturali.it.
[7] http://www.icr.arti.beniculturali.it.

As for specific, local activities within the CRM sector, a number of Italian regions and local archaeological offices, often in collaboration, have built up their own projects in which data encoding and structuring must conform to the agreed central standards. In this context, a good example is represented by the *Carta Archeologica del Rischio Territoriale* (CART) project, coordinated by the *Istituto Beni Culturali of the Regione Emilia Romagna*[8]. The main purpose of the CART project is to solve the everyday conflict between the modern urban-planning development and the cultural heritage safeguard, through the use of computer technologies and the production of a modern digital archaeological risk area map as an effective and cost-saving tool for urban and rural planning.

2.2. Research projects

With reference to the projects carried out by Italian academic and research institutes, the presence of two investigative sectors seems to be characteristic: the first one pertains to regional studies, aimed at analysing large landscapes; the second one is oriented towards the study of ancient towns and their surrounding territory. As far as the safeguard problems are concerned –and here we can note a possible close relationship to the policy of CRM projects– these research projects are aimed at estimating in a GIS environment the degree of vulnerability, through the spotting of geological risks, for instance seismic and hydrogeologic natural catastrophes (a problem particularly felt in Italy).

The analysis of ancient towns is particularly developed in Italy. The research methodology focuses on the analysis and interpretation of the development from the pre-urban phases up to the post-ancient transformations. Particular attention is also devoted to the analysis of environmental factors (climate, geographical position, geomorphology, etc.) that have contributed to the formation of each site and to the definition of archaeological distributions and activity areas within a historically coherent context. As an example of ancient towns analysed with modern computer technologies we can cite Padova, Modena, Faenza, Forlì, Roma, Catania, Termini Imerese and the various towns analysed and published in the series *Città antiche in Italia* series[9], Atri, Todi, Piacenza, Ancona and Venosa.

Finally, as far as the application of GIS in archaeological excavations is concerned, a significant development can be noticed in the last few years. For example, projects have been carried out in the medieval Tuscan settlements (e.g. Poggio Imperiale at Poggibonsi and Rocca San Silvestro), in the Etruscan towns (urban plateau of Cerveteri), in Campania (Cuma and Pontecagnano) and in Puglia (Messapian settlements).

2.3. Technological aspects

From a technical point of view, the survey has shown that at the end of the 1990s both Unix workstations and PCs were used (Djindjian, 1998). This choice reflects current

[8] http://www.ibc.regione.emilia-romagna.it.
[9] http://web.tin.it/tabularium/cai.html.

market tendencies and the growing use of increasingly powerful PC workstations. As far as software packages are concerned, there is a wide panorama of solutions and this underlines the primary necessity, within an archaeological information system, to confront the problem of integration. Workstations generally comprise a GIS, to which a database and CAD software are connected.

The choice of software is strictly linked to the distinction between the two above-mentioned sectors. CRM projects are usually lengthier, have permanent personnel and sound financial budgets. The most used solutions are ArcInfo for GIS, and Oracle as a database, running on a Unix workstation. The projects carried out in the framework of research institutions are usually of a shorter duration, in connection with the available budget, and are managed by a very restricted group of researchers. In these projects, generally run on PCs, the most widely used systems are ArcView for GIS or other academic software available to the public and therefore not too expensive, and as a database Microsoft Access. Lastly, for CAD products, AutoCAD seems to be the most popular.

Interest in the use of standards for the uniformity of data description and recording is mostly felt in CRM projects. In the projects carried out by research institutions, however, scholars are more likely to create their own criteria of description, related to the goal of the research itself. In the last years, the use of markup languages for the encoding and transfer of electronic documents (i.e. SGML, XML) has generally aroused lively interest.

Spatial Analysis techniques, both inter- and intra-site, are considered the to be the final goal of GIS applications, as the spatial element constitutes the very innovation of these systems. Notwithstanding this, by the end of the 1990s very few projects in Italy were interested in the investigation of topics connected both to the modelling of settlement distribution within a territory or of archaeological records within a settlement, or the simulation of settlement processes. This last step, which is now well tested, is fundamental to the aims of heritage management and planning, through the identification of variables that characterise the choice of place and the distributive parameters of features, also correlated with time.

Finally, with respect to the problems of information diffusion, it is interesting to note that within the Italian projects collected in our survey, the Internet was not a very frequent tool for on-line data diffusion. At the same time, the use of the web is growing in size and importance in this sector of computer applications.

3. AN ARCHAEOLOGICAL INFORMATION SYSTEM FOR THE CERVETERI EXCAVATIONS

At the very beginning of the Caere Project (Moscati, 1998c), it was the enquiry itself that suggested our procedure along certain successive well defined phases, initially devoted to the definition of some methodological and technical problems. These included data representation and encoding; data structuring and formalisation of the procedures; use of descriptive standards; alphanumerical, graphical and cartographic data analysis and image processing; application of inter- and intra-site Spatial Analysis; definition and testing

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of new software; application of our model to Caeretan data; establishment of a parallel multimedia product for data diffusion and conservation.

In subsequent years, the development of the Caere Project (Moscati, 2000) has made it possible to establish a unique and comprehensive model for the digitization of excavation data, carried out in the central area of the urban plateau of the ancient Etruscan town of Cerveteri (Figure 6.1). In particular, the information system as designed has been applied to the excavation area of the Vigna Parrocchiale (Figure 6.2), close to the Roman theatre, where several archaeological phases have been identified, beginning in the Villanovan period and following through until the Roman (Moscati, 2001).

The project now concentrates on the combination of archaeological data, which comes from survey, excavations, laboratory analyses and documentary research, with methods developed over many years of experimentation in computer applications in archaeology, including the use of a GIS and other related technologies. Subsequent operating stages are therefore aimed at developing the integration of different systems, the normalisation of descriptive language and standardisation of technical and methodological tools.

The Caere Project has been designed so as to incorporate data from various levels of detail, ranging from the analysis of the surrounding territory to the detailed level of excavation. This complex computational methodology aims also at integrating the various forms of previous research conducted by the Institute, including statistical analysis and databases. From the outset of the project, much attention has been placed upon the discussion of methodological and technical issues specific to the research, to form a framework for data acquisition and processing. From a methodological point of view, the first stages of data description and representation have been focused on the definition of data models, aimed at outlining the formation of archaeological data (Moscati, in press).

Central to the aims of the Caere Project has been an emphasis on integrating various computer applications in order to gain a comprehensive and complete knowledge of the ancient landscape and the organisation of the town. This integration has been achieved through the construction of a relational database and its unification with a multimedia system. At the core of the framework is the GIS platform, which provides a pivotal fulcrum on which the data hinges. GIS technology is fundamental to this project, as it has extended the analytical processes by integrating geographical and attribute data, and provided a forum in which to draw together the diverse datasets of the project.

The need for a highly formalised language in order to avoid ambiguities and misunderstandings has led to the choice of Standard Generalized Markup Language (SGML) as the most suitable method to encode in hypertext format the yearly excavation diaries (Moscati, Mariotti & Limata, 1999). SGML is an encoding language for electronic documents, focused most of all on the description of data internal structure (Figure 6.3). In an SGML document, the strings of text that have different semantic content are encoded differently even if they share the same typesetting characteristics. The use of a markup language permits the *a posteriori* establishment of terminological lists, the definition of well-defined contexts, theability to set up hyperlinks and to supplement

and interrogate the original text. The choice of the Internet in order to distribute our information has also involved a study for the conversion of SGML documents into XML, a more recent encoding language, which derives from SGML (Bonincontro, 2001).

The SGML encoding procedure is independent of hardware and software and thus guarantees the easy transfer of files to different systems. Further, the use of open exchange format files and the modular structure of the GIS, customised with scripting languages has extended the capacity for cross-platform interoperability. The capability of this information system, therefore, has been expanded and the further choice of commonly available software, such as AutoCAD, ArcView and Access for the processing of both alphanumerical and geographic data has accomplished this task. In addition, the adoption of an on-line GIS, using MapGuide software, has helped to increase the level of interoperability of the data and has created the paradigm for an Internet-based research.

After assessing, the problems related to the digital cartographic representation of the urban plateau and in particular the parameters for the construction of a locational Digital Terrain Model (Figure 6.4), the techniques of Spatial Analysis have been applied. They represent a tool devoted to the investigation of criteria that are at the basis of archaeological spatial distributions and respond to a programmatic choice in land and site occupation. The ability to query and generate new data is a fundamental characteristic of a GIS, and it is through the concept of spatial "relationships" that these functions offer a new and stimulating approach to the study of regional and urban space. One technique in particular has been used within this project, Viewshed Analysis, which has been applied to investigate the spatial relationships between the archaeological monuments located both on the urban plateau and in the Banditaccia necropolis (Ceccarelli, 2001).

Within the project, an information retrieval procedure has been designed (Figure 6.5), which queries the SGML files and visualises the results through an Internet browser (Barchesi, 2001). In this manner, an investigation has been made of the potential of multimedia systems, not only from a technical point of view but also to work towards achieving high levels of interoperability between heterogeneous data sources and computer platforms. The aim is to improve dialogue between scientists, which is generally relegated to the more traditional printed publications. This approach –based on the principle that information itself is not sufficient unless linked by new forms of knowledge representation– has enabled the recreation in a digital environment, and in an interactive manner, of the main phases of the terrain "readings".

The ability to clearly communicate results has been central in the ideology of the project. Therefore, the structure of the project has aimed at obtaining a multimedia solution for the general topographic publication of the Vigna Parrocchiale excavation. The purpose has been to experiment with innovative methodologies for integration, data retrieval and ability to query excavation material, and then utilise the Internet as a new medium for the electronic publication of archaeological data.

Because of its form of construction and general characteristics, the model can be applied to the archiving, managing and querying of textual data, using such information

as excavation reports, archaeological finds and image data (e.g. graphics and photographs) as well as bibliographic information (Mariotti, 2001). In fact, the development of this prototype has led to a model structure that may be applied to any archaeological context, as has been confirmed by the study of other archaeological features in the urban area.

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