LARGE SCALE SPATIAL DATABASE SUPPORTING ARCHAEOLOGICAL RESEARCH

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KEY WORDS: cultural heritage documentation , spatial database, GIS, close range, photogrammetry.

ABSTRACT

The experiences in the field of the documentation and the information management to preserve archaeological heritage have led to single out the interdisciplinary cooperation as essential element, particularly inside an archaeological mission where knowledges mix and there is a proliferation of information differently located on the field. This kind of cooperation musn't restrict itself to a simply comprehension and reworking of data *in situ*. Thanks to the possibility to create common records, we have the opportunity to possess different kind of data inside a single integrated spatial system, where new interdisciplinary information could develop from recorded data.
This approach must be strongly followed up when a number of research organizations of different nationality and cities are working together during a limitated time as in the Archaeological Mission of Hierapolis of Phrygia (Turkey) where our studies in this field are focused.
In the past, we already outlined a Geographical Information System, carried out on the base of a digital map at the urban scale of the whole archaeological site. Now, in this communication, we present a part of the system concerning a limitated excavation zone which defines a single residential block of the ancient city and wich is assumed as sample area for testing, at the very large scale, the employment of spatial research methodologies integrated with archaeological data.
Following problems are probed in order to allow and improve the management and the spatiotemporal analysis of documentation:

- armonization of spatial data to permit different scaled map representations (mainly at urban and architectural scale) inside a unique GIS structure;
- concerning the normalization of spatial data, obtained by surveys of different nature, the research has been focused on the definition of homogeneous levels of positional accuracy;
- it is in progress a research to coordinate the extensive nature of the archaeological objects (such as territory and environment, urban and architectural structures, excavation areas) with the detailed and defined character of the archaeological data acquired on the field. The products of their rielaborations and the hypotheses of study and reconstruction have a continue nature again (stratigraphic units, wall stratigraphic units, areas with homogeneous temporal phase,…); so they need to be represented by entities having a surface extension.

1. INTRODUCTION

Despite the common matrix to make use of modern methodologies of survey, the approaches to the structure planning of (G)IS dedicated to the documantation of cultural heritage are much various today.
In this article we propose our point of view about this subject, developed in the field of archaeological research throught the documentation experiences that we have realized within the Italian Archaeological Mission of Hierapolis of Phrygia (Turkey).
During the last few years (2003-04) we have got ahead the organization of the ancient city GIS; the multiscale structure of such GIS has been formulated to satisfy requirements of the urban scale involving the entire ancient city and different kinds of monuments placed out the city walls. Now we are working to implement the multiscale structure migrating from the large urban scale to the larger ones, both architectural and archaeological scales.
Within this field we can say that now some arguments can be regarded as largely shareable:

- geographic information systems, or (referenced) information systems, are well accepted as the proper instruments through which the rich documentation related to cultural heritage can be managed; thanks to their capability to operate with complex and heterogeneous data having multidisciplinar character;
- the description and the representation of environmental and archaeological sites is formulated using cartographic maps instead of simple plans that are not used anymore.

Another fact can be evidenced. Between many identified experiences it is frequent to find that the structuring of information systems is generated as a function of finalities or aims planned from the beginning. That is, the logic which leads the organization of the spatial information is deduced by the objectives to achieve.
We could think to some GIS structure developed according to conservation projects: the purpose of the plan itself (for example the static quality of an architectonic object damaged by a traumatic event like an earthquake or a fire otherwise the material deterioration) shapes the data organization, often reducing them, and consequently the obtainable information. Frequently the thematic arrangement of the database is the first item which moulds the spatial features.
This is the reason why our present efforts are aimed to master the characterization of the spatial database at the architectural scale, following a principle of development set out on a generality nature.
Actually the research is focused on a residential block in the centre of the ancient city of Hierapolis near the imposing roman theatre. The excavation area of the *insula 104* includes both the block and the streets which marked its boundary (in the central zone of Hierapolis the road system follows the regular and strict rule of the Hippodamus plant: the streets (*stenopoi*) are

orthogonal each other and bound rectangular block of 30x70 metres following respectively the course of the contour lines and the direction of the ruling gradient).
From 1989 the excavations have identified two *domus* inside the *insula 104*; now they are both brougth to light by archaeologists. One of them is enriched with a ionic peristyle and guest rooms decorated with *sectilia pavimenta* and fresco walls.
During the summer season of 2004, the excavation reached the extent of the whole block and, to investigate the knowledges about the various reuses and occupations that followed one another during the nine centuries of live of this residential block, a metric and thematic documentation of the rooms has been asked for a larger scale.
As it will possible to observe, after a general 3d topographic survey thanks to which we realised the representation with a scale included between 1:100 and 1:200 (plan and section), the new closer examinations, concentrated inside some peculiar rooms of the *domus* and carried out throught topographic and photogrammetric integrated survey, are oriented to the restitution of representation in horizontal and vertical sections.

2. CONSIDERATIONS ON SPATIAL DATABASE

Since digital cartography is arised and evolved trying to regenerate characters of generality proper of the traditional cartography, one can legitimately wonder whether this kind of evolution could be supposed and expressed using spatial databases at the architectonical scale.
The evolution of the architectonic documentation has developed the editing of many grafic language rules to create bidimensional representations on different planes of projection, having each one peculiar characteristics. We could think to the vertical sections or plan projections throught which we describe the architectonic objects; each of them has proper signs and provides a restricted representation of the same object. The abstraction of the spatial reality and the generation of its model is a more complex result to achieve especially when the object is articulated, temporarily changeable, superficially and materially disomogeneous.
For these reasons one of the main element to which we are following, to harmonize data both at urban and architectonic scale and to conform omogeneus levels of accuracy, is the control of the processes of acquisition and organization.
First of all there is a continuous an underlying theme which links spatial data at different scales since the principles of acquisition of them follow an approache which is repeted using similar methodologies but with a hierarchical order to realize maps and models differently scaled. That means that not only the object but its contents too are integrated and have to be analized in their correct spatial contest by an appropriate scaled map.
Since archaeologists and many other specialists observe and study metric documentation of architectural structures, a logical data organization regarding diversificate nature of analisys is needed, due to the fact that different methodological and instrumental approaches are used, and so any kind of spatial standardization have to be established.
During the last two excavation seasons dedicated to the survey of the *insula 104* a huge amount of data have been collected. Until now the operations carried out in the area, acquired with an homogeneous process of control on data, could be schematized in this way:

- the preavious realization of the topographic network aimed to the construction of Hierapolis 1:1000 scale map enabled to create a local lower level network to survey the block and to enable the different scale representation congruent to the purposes of architectonic restitution (1:100)
- during the season 2003 we used well known techniques of raster data registering by control point to recover a large number of archaeological drawings concerning floors configuration; in this way we ensured levels of accuracy comparable to the topographic survey;
- in 2004 a more detailed survey has been demanded so the terrain operations have been organized to carry out photogrammetric plottings and orthoprojected maps of some floors and walls surfaces.

Figure 1 – A portion of a thematic map implemented in the urban GIS and representing the residential block near the roman theatre.

Figure 2. – A view of the ionic peristyle at the centre of the *domus* located in *insula 104*.

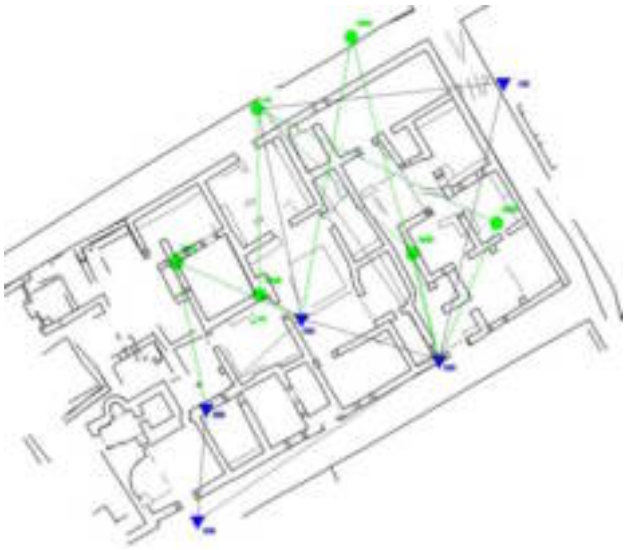

Figure 3. – Two levels of topographic network enclosing the block.

Figure 4. Residential block plan with photogrammetric models aimed to more detailed restitutions along the longitudinal section.

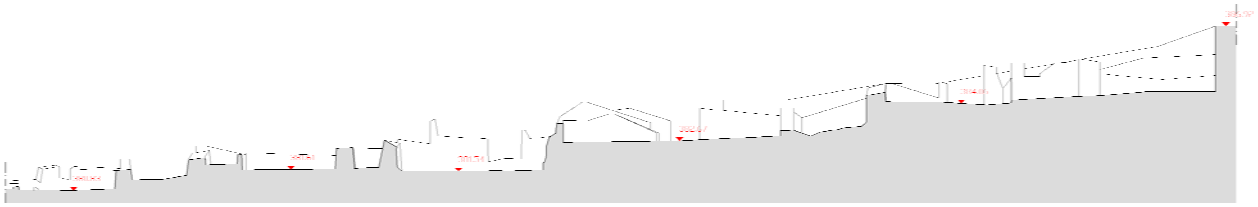

Figure 5. Longitudinal section before closest range mastering.

As a consequence, when we structure data we must necessarily investigate even the relationships between spatial and archaeological documentation data, even the knowledge of the standard procedures adopted by archaeologists to catalogate and record the escavation data (these last are characterized by a high spatial value).
But, first of all, it's necessary to investigate and single out a correct spatial model which lets the managing of different information in a better way.
Among the identified issues, the one we would chiefly underline as the most significant is the diversity in the use of the projection plane, since it marks off the difference between the map rappresentation at large scale and the architectonic one. Even if both of these kind of representations take shape like abstraction of the reality, in the first case the projection plane don't change its position and its proper reference system; in the second one, the projection planes, both horizontal and vertical, modify their reference frames side by side, for whose decodification are required particular signs. In fact we meet problems when we try to overcome the gap generated by the scale change and by the different detail level, but even because of the different way to conceive and represent the real space.
For example, it's possible to find this dichotomy when we are trying to manage elements having a linear extension, like the top of the walls of ruins, in the same way as in topografic databases streets are represented. The employment of reaches and nodes, proper entities of the street networks, could generate a consistent model but various possible interpretation request a less rigid scheme.

Especially in the archaeological field, as long as we think that the intersection between two or more building partitions is often rich of complessity as it is pointed out throught the individuation of the wall stratigraphic units. In this position, spatially well identifiable, more temporal phases could be identified throught the stratiphication and the diversification of constructive typologies, that are superimposed or tooth or leane against one to the others.
At the same way, while in cartography the eaves level represents an almost homogeneous information for the entire building, an elevation point located over the top of a wall in a archaeological structure can't be considered a valid and exhaustive information, thus walls haven't got top surfaces featured by a costant level.
It seems that, as we could hardly set out characters of generality for vectorial plans at the architectonic scale, we exploit the capacities of the GIS structure to provide an articolated combination of different thematic bases to which gradually join sets of data of distint nature.

3. GIS STRUCTURE

Usually, in GIS planning, matters to be considered are many. Among first ones there is the diverse nature of different data collections, that enables to single out precise methods and formats of archiving, or different kind of relations that have to be fix among sets and subsets of data to preview criteria of retrieval and comparison. Further more it's strictly necessary to

choose the general system architecture and the features of database engine.
Here we are interested to outline mainly a character of general organization, pointing out that some portions of system have arised a fairly good level of implementation, while for others we succeded the data conservation singling out the proper kind and format of collection, but not a final implementation.
First of all we specify what we have just said, i.e. we are referring to the spatial sphere of system; on the whole we singled out 3 principal class of data:

a. raw data or low-processed data, collected to be used in the future
b. diverse nature survey elaborations, provided by different kind of data processings and setting an explorable complex of metric documentation.
c. synthesis of elaborations, often offered in a 3d configuration. The main object of this class is not to enable further capabilitites of study or analisys upon architectural object or portions of it, but better to represent and comunicate to a larger fruition, results of studies and achieved interpretations of reality. (VR-models, concerning reconstructions of architectural structures set up, are going to be included in this class)

The first class of data has reason to exist for almost two purposes: firstly because modern techniques of data acquisition are featured by very high capabilities to make fast and productive acquisition phase, while they need longer working time and high resources to be processed and elaborated.
The second reason is more connected with archaeological field of study; we are observing, in fact, a relative loss of use of archaeological classical direct measure techniques founded upon typical reference grids. The growing complexity of general research lead to delegate different specialists in data production, obviously even in survey.
An important topic that we outlined throught the cooperation with archaeologists is about marking points on diggings. Known coordinates points (especially elevation points), constitute a fundamental reference to enable continuous updating of excavations data, strictly necessary to institute stratigraphic relationships among different (stratigraphic) units.
In the second class of data are included products of different elaboration processings which constitute diverse architectural maps, explorable and inquirable by GIS functionalities.

Figure 6. Difficult use of archaeological reference grids in articulated architectural structures

Figure 7. Main classes of data and their subset.

The following two pictures show an example of a third class model; the 3d model is generated from various data collected in Gis structure belonging to the first two classes of data.

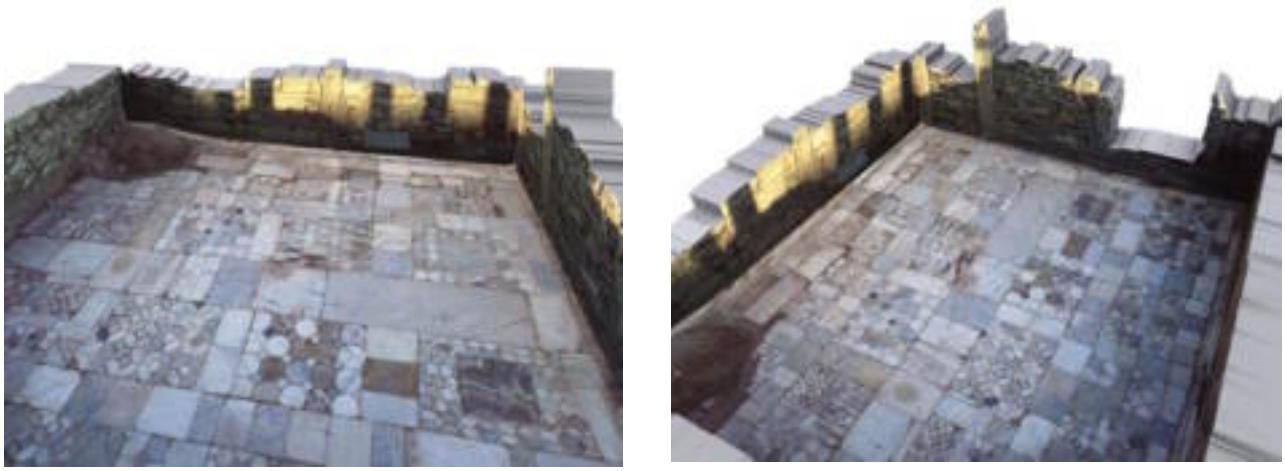

Figure 8-9. Views of 3d model of A195 room. (Realized by P. Testa)

4. PERSPECTIVES

Since our prefixed goal was to define structure and features of topoghrphical database at the architectural and archaeological scale, at the moment we can only outline further working perspectives and not conclusions.
Our present propose provided rather good results with reference to possible link and comparisons with thematic data collections regarding architectural analyses, while it must be developed the possible interchance with archives derived from excavations collection.

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ACKNOWLEDGEMENTS

We thank prof. A. P Zaccaria Ruggiu (Cà Foscari – Venice), responsible of *Insula 104* excavations, and prof. F. D'Andria (University of Lecce), Italian Archaeological Mission Director, for the cooperation they asked us.