INTEGRATED AND MULTISCALE SPATIAL DATA TO BASE A GIS FOR THE ANCIENT CITY OF HIERAPOLIS IN PHRYGIA

B. Astori [(*)], V. Bonora[(*)], A. Spanò [(*)]

[(*)]DINSE, Politecnico di Torino, II Facoltà di Architettura, viale Mattioli 39 – 10125 Torino – Italy

bruno.astori@polito.it -valentina.bonora@polito.it - spano@archi.polito.it

KEYWORDS: Archaeological GIS, Cultural heritage, Cartography, Digital Photogrammetry, Databases, Digital images

ABSTRACT

Many historycal, architectural and archaelogical studies pointed on ruins and excavations of the ancient city of Hierapolis, had provided building plans that have been recently collected in a urban map carried out through traverses surveying. (A GPS network connected to total station closed traverses assured reliable accuracy levels required for urban scale map 1:1000)

The last project (2002), integrating relief terrain representation to the map, and global spatial data accuracy assessment, offered the chance to gain a digital map of the site. This topographical base is the fundamental spatial information of the growing GIS, aimed to manage heterogeneous nature data, obtained from different fields of study.

This paper underline the need of multiscale spatial data for archaeological GIS; at the same time we explain the reasons of helpful features of this proper site map. Moreover, the continuous map updating is managed together with geometric entities editings; this task implies suitable reorganization of data.

On the close-range side, large scale surveys are warmly requested; according to the urban scale sphere, we integrate just acquired data with new focused datasets, achieved by digital photogrammetry or with topographic methods. Purposes are various: ruins stability control, modern walls analyses, falling down studies, excavations documentation that need close range nadiral images (we used a jib-crane for acquisitions).

Every level and type of geometric data is the metric reference for a huge amount of data sets collected in a relational database: images storages and alphanumeric data sets, come, at the moment, from a typical architectural interpretation of wall stone or marble blocks. Sharing informations is one of the main need of an archaeological site managing, and a carefully planned GIS can aid to gain the goal.

1. INTRODUCTION

One of the main features of the under processing GIS of the city of Hierapolis is the multiscale vocation; this peculiarity is needed by studies intending to exploit it. They ask different levels of analysis on investigated objects, from territory to archaelogical finds or architectural elements.

The most important target is to gain a full integration between three different range of study, within them various disciplines, co-operating in the archaeological Mission, can share data and information. These three range of study, who need reliable digital maps differently scaled and relational database on purpose planned to collect images and alfa-numeric data, are the following: urban-territorial level, architectural level, and excavations level.

Most operative units working on the site, produce heterogeneous data, and most of all consists in digital format; many steps have been done to reach digital managing and we think that a significant grant we can offer to everyone is to provide proper maps and architectural scaled plans accomplished with topographic methods.

Further than digital data nature, spread in every field of study, the main samples of managing data through databases are at least two.

- o GIS platform to catalogue excavations datasets (archaeologists administrate these applications - D'Andria F., 1997).
- o A relational database aimed to collect and manage datasets concerning the identification of architectural walls blocks; this is an important tool to lay reconstructive hypothesis that are necessary to found a restoration project. (Spanò A., Bonino R., Massa A., in press)

We consider the 1:1000 scale site map a starting point to establish a correct geographic information system devoted to archaeological site (more details on mapping process in: Astori B. Spanò A., in press). One of the main objective that we propose to master is to take care and spot what requirements about spatial data ancient buildings and excavations studies will ask.

A approach pursuing these topics is presented.

2. URBAN MAP FEATURES

The multiscale feature of GIS has premises on features of urban map. The map achievement didn't follow a standard process, since, before last decade, a proper setting up of topographic networks and a general aerial-photogrammetric survey couldn't come true. Since archaeological Mission foundation, all estensive study activities on the area of Hierapolis were applied to close-range structures knowledge and description, and only a sketch plan of city order was fulfilled. Besides, during last years, two order of traverses have been set up. The first order

network encompass the hole ancient city and surroundings; and it was arranged by a GPS survey (Fig. 1).

At the same time, a great deal of an inferior order of total station traverses were set to encompass buildings, excavation areas or other areas of interest (these networks, largely spread on ancient city territory, have the role to base topographic detailed surveys on architectural structures and ruins). After that, a methodical weld of second order networks to the GPS control points has been applied in order to achieve the reliable and updated site

plan. Measures of these last points have been performed with topographic intersection method.

More recently, Turkish government provided some sheets of a 1:500 scale map of the site: unfortunately it was rather outdated and it was not reliable for planimetric contents but, as usual, contours and elevation points were surely good (we also tested them in proximity of buildings).

This map has been used to extract terrain relief data, but a deformation recovering treatment has been necessary to ensure accuracy level required for 1:1000 scale . So, sheets have been turned to raster format, and images have been submited to a third order polynomial transformation, using grids nodes as control points.

The best running warp for turkish map is the same spotted to register satellite images; that suggest deformation dishomogeneity.

After deformation recovering, altimetric data have been convert to vector in order to obtain homogeneous vectorial format for final map. While a set of control points enables computing of preliminary images recovering (they correspond to nodes of map grids of known co-ordinates– Fig. 2), other points fixed by measures on field were used to perform the next rubber sheeting trasformation aimed to fit vectorial altimetric data to planimetric map. (Fig. 3) Following images show some main phases of plano-altimetric map achievement.
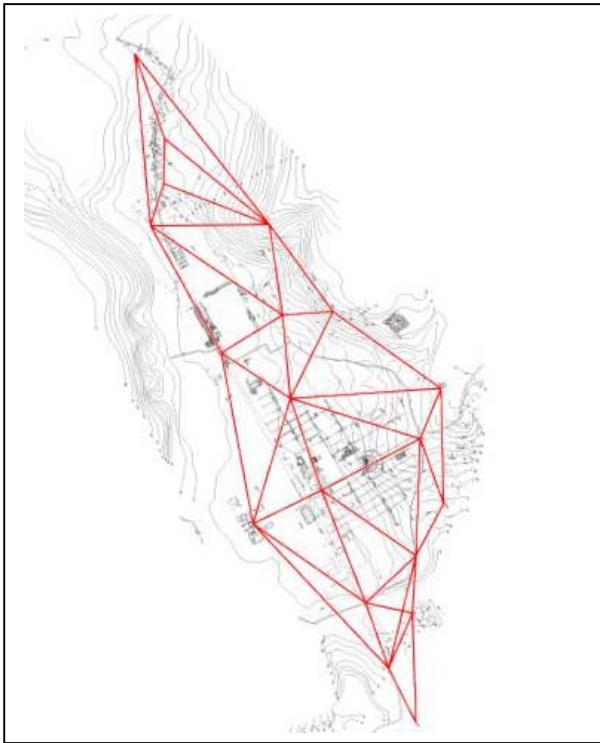
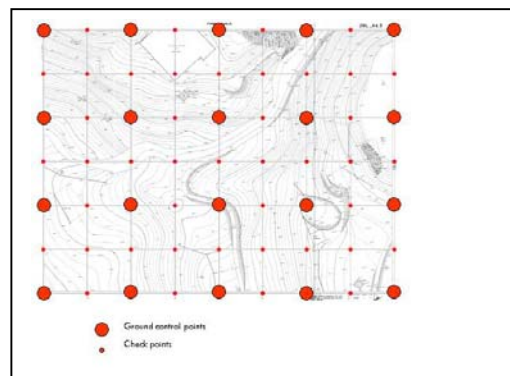Figure 1 – Main GPS network. It lies on urban area and surroundings (necropolis)

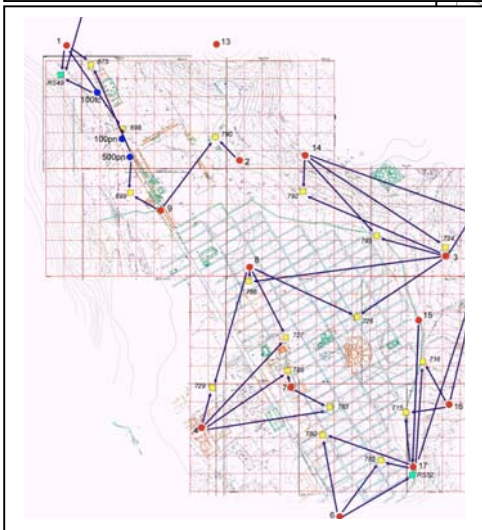Figure 2 - Control points to recover map deformation and check points to test it.

Figure 3 – Topographic intersections on searched out points; they are purposed to compute a rubber sheeting registration of two datasets.

Figure 4 – An extract of final map

The mapping process described means two operative phases: we gained first a planimetric description of the site, that has thematic contents fit to usual archaeological sites representations, while spatial contents of site plan make it similar to a cartographic product.

This kind of result turns out very useful. The matter is not about the fitness to have spatial information available, since this criterion is held in great esteem, even and especially by archologists, Architecture historians and other researchers working on cultural heritage; nowadays, in fact, archeological and historical investigations upon ancient cities are managed in a tigh correlation with environment and territorial inquiries.

The map we hold need further editing activities on geometric entities; these improvements are aimed to satisfy many requirements of topological relationships that possible spatial analyses a GIS can run.

At the moment this cartographic representation of the site is not fully efficient towards updated managing systems, but surely it is extremely rich of information that is helpful to enlighten city organization. (two example are the positional and dimensional indications of hipogeal rooms, isolated or grouped, and the second item is about the road net: we can read on the map much more streets than those excavated, because it shows scattered signs of them.)

It's not difficult to guess that these merits of map arise from such acquisition processes; that just because many typical data of larger scales are available on 1:1000 scale map (Fig. 7) Following the spatial data quality scheme, we try to point out what datasets and for what feature, information is superior or better set up than a similar map at the same scale provide:

Overall positional accuracy; only on buildings or ruins areas, it exceed the one requested by 1:1000 scale; that is offered by complete topographic surveys on field.

Overall thematic accuracy; on the same areas than above, and for the same reason, this parameter is even exceeded. Looking at figures 7 and 8, it's clear that building plan is not just a plot, because falling down material hide architectural shape and rooms distribution. Building plans are graphic results of deep studies.

Overall temporal accuracy is a particularly necessary trait of archaeological sites representations because of the high level of environmental trasformations (excavations, restorations).
The density and distribution of local networks and fixed points, issued for mapping, enable easier updatings.

One of the main gap that distinguish Hierapolis map from a typical urban map is the type of description of buildings. While in a traditional urban map, areal entities or simply polilines of buildings, stand for the intersection line among volume and ground, here not.

Geometric entities showing buildings or ruins are directly issued from architectural surveys, so they simbolize a section line defined by a virtual plane cutting architectural structures at a height of about 1 meter from floor. (In architectural survey and drawings, the height from floor of this section plane, can fluctuate; generally it set to show the so called lower resistance lines, in order to provide so much information as possible)

Figure 5 – The sketch shows position of polilines nodes (or areal feature nodes) typical of photogrammetric plotting.
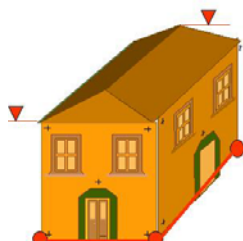

Figure 6 – Graphic processing that shows horizontal virtual cutting plane on *Terme Chiesa*, used in architectural representation
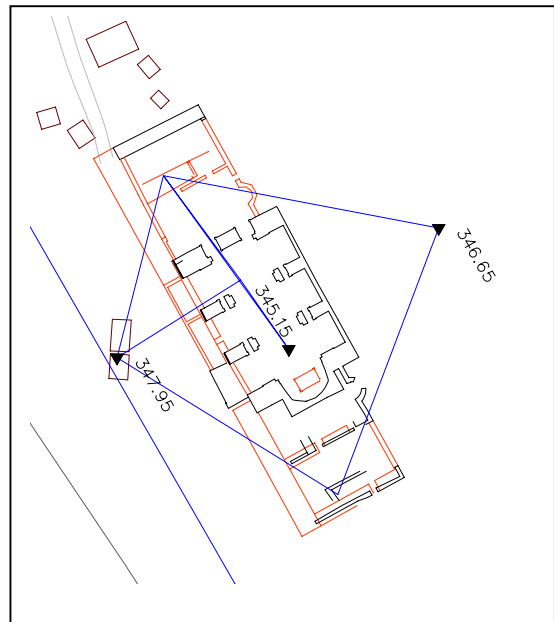

Figure 7 – *Terme Chiesa* plan with net scheme.

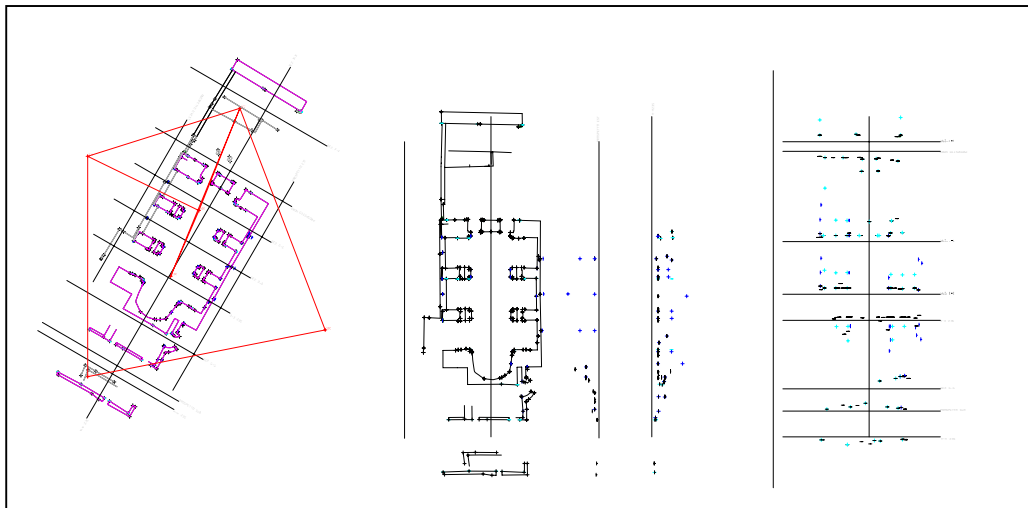Figure 8 – A photo of *Terme Chiesa* acquired from Areostatic balloon.

Figure 9 – Study of architectural sections, based on topographic detailed survey.

Images took from a areostatic balloon, showing falling down and presence of blocks' obstruction, compose a significant and rich photographic archive; it is in fact foreseen to make them available inside GIS, linking them to geometric features.

We likewise think that height data walls, extracting from architectural large scale sections (Fig. 9), would be an interesting and helpful information to provide among map (Fig.10). It would be easily clear what walls are hardly emerging from terrain, and what are undamaged; such transfers of differently scaled data take part to the data reorganization we are studying for GIS settings.

(right) Figure 10 – Integration of large scale height points to the area of *Terme Chiesa* in the map.

ambito
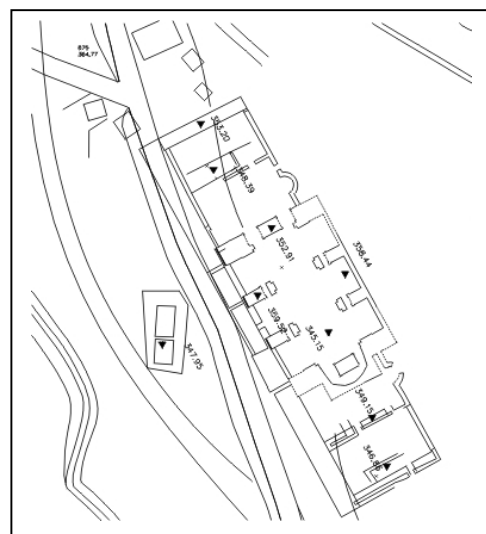
3. INTEGRATED SURVEYING TECHNIQUES TO ARRANGE LARGE SCALE SPATIAL BASES

On the side of close-range architectural analyses and according to the previous urban level, acquisition and processing surveying data are directed to integrate and master just revealed scenery. The main purpose is to accomplish spatial bases characterized by high informative power.

Adding to general architectural shape and distribution of buildings, uniformly recorded for each architectural structure, we intend to make available spatial bases enabling different and further investigations:

- o Reading of architectural Element
- o Materials analyses
- o Decorations analyses
- o Clear inscription recording
- o Tecnologic appliance analyses
- o Deterioration materials analyses
- o Instability structures analyses

Highly considering the wide range of documentation requirements regarding monuments and their parts, positional accuracy is not the only and most important parameter to take care. Architectural historians, archaeologists and other researchers often need and prefer a photographic data.

Not always orthophotos are strictly requested, so if analytical rectifications establish a satisfactory result, it would be reasonable to plan and arrange proper rectified images archives. Digital data collection, recorded in suitable database, can retain the prospective chance to extract further spatial datasets in different temporal phases.

Next example shows an experience of enlarged data acquisition and focused processings. (Fig. 11)

To arrange a 1:50 crossing section of a suffering instability building (again *Terme Chiesa*), we exploited different surveying metodologies and we performed distinct processing according to obtain a result where information are differently shared.

Acquisition data:

- o topographic detailed survey of adjacent points on structure section (the first aim was to quantify the East wall overhanging)
- o Stereoscopic photographs acquisition of inside facades of building and control points survey. Such data enabled a photogrammetric orientation of a model with a limited plotting of most damaged part of structure. Other facades data have been used to carry out a general analytical rctification of images.

These last images are not appointed to vector extraction, but they are mainly devoted to support readings and analyses in advance listed; result of these activities will be collected in the intended extension of relational database
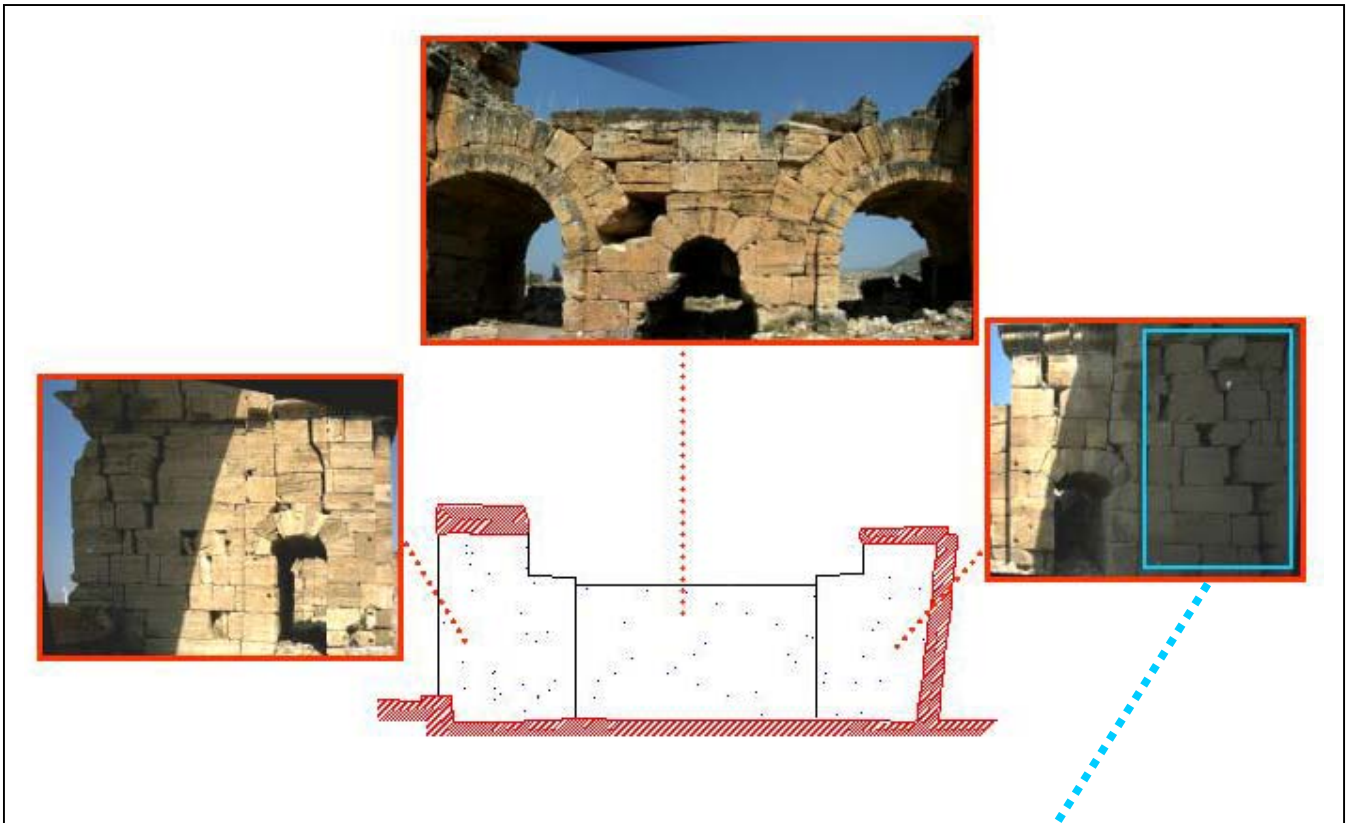
Figure 11 – In the centre a trasversal section gained by a total station reflectorless measures (3 aligned station points have been necessary, and the section line is described by round 10 cm spaced points). Photographs are rectified by sets of control points also enabling photogrammetric orientations.
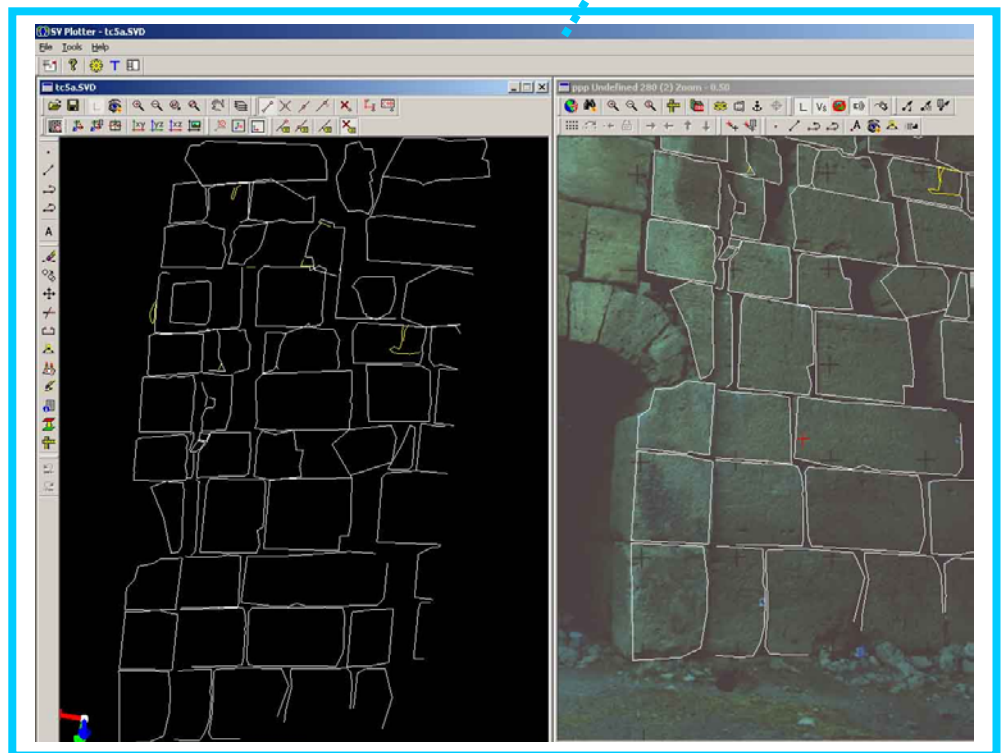

Figure 12 – Digital photogrammetric application to plot the most injured portion of large block wall.

Till now the just implemented portion of relational database collects data about block and their features. The general purpose of this managing is to identy possible positions of blocks in the supposed theater *scena* reconstruction.

Next activity is aimed to enlarge database to walls features collection. Many implemented structures of data obviously fit to walls analyses.

Figure 13 – A portion of the data entry interface of teater block.

Figure 14 – Theater blocks tidely placed near the building.

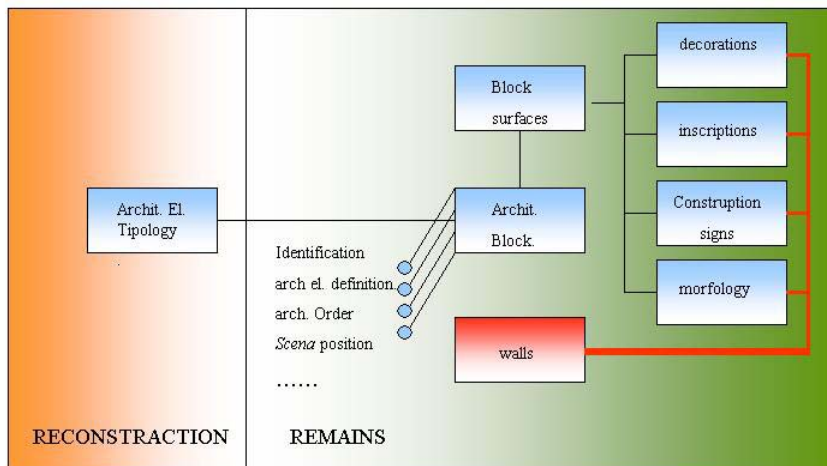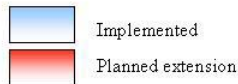Figure 15 – An extract of rectified walls image

Figure 16 – An essential scheme of the conceptual model core.

REFERENCES

About this project:

Astori B., Spanò A., *La cartografia in scala 1:1000 della citta' di Hierapolis*, in press

Spanò A., Bonino R., Massa A., *Integrazione di metodologie di rilievo e gestione dati tramite DBMS nel SIT multiscala della citta' di Hierapolis*, in press

Beinat A., Marchesini A., Visintini D., 2002, *Il rilievo cartografico di tell mishrife (Siria centrale) con GPS e fotocamere non-metriche,* in Proceedings of National conference ASITA, Perugia.

Achille C., Balletti C., Brumana R., Monti G., Monti C., Savi C., 2002. *Georeferenziazione dei beni e strutturazione gis a supporto della redazione della carta del rischio dei beni culturali: verso un capitolato*, in Proceedings of National conference ASITA, Perugia.

D'Andria F. (a cura di), 1997. *Metodologie di catalogazione dei beni archeologici*, Beni archeologici – Conoscenza e Tecnologie, quaderno 1.1, Lecce Bari.

http://www.thebanmappingproject.com/
http://www.isotc211.org/