Preventive Archaeology: Towards a Technological Integrated Solution

Sorin Hermon
STARC - The Cyprus Institute, Cyprus. *hermon@cyi.ac.cy*

Valentina Vassallo
,STARC - The Cyprus Institute, Cyprus. *vassallo@cyi.ac.cy*

Abstract:
The topic presented here is an on-going research which has been carried out at the Science and Technology in Archaeology Research Center (STARC) of The Cyprus Institute. The aim of the project is to evaluate and elaborate a technological integrated solution for rescue and preventive archaeology, urban planning and Cultural Heritage management. It will also be able to receive and handle various constraints set by different users. Therefore, in order to simulate and test tools and methodology, the archaeological excavation of Agios Georgios Hill in Lefkosia (Cyprus) has been used as a case study. The possibility to use different techniques of data acquisition, documentation, interpretation and visualization will allow to evaluate and propose alternatives and possible scenarios.

Key Words: *Integrated Technologies, Urban Planning, Preventive Archaeology*

Introduction

Preventive archaeology has recently received considerable interest in archaeology. Its importance is directly connected to the development of a site or to the growing of society in general.

The growth of a city is determined by several parameters such as cultural, historical and archaeological, economic, political, etc. Planning strategies are one of these parameters.

Such a strategy has to take into consideration the protection and management of multitudinous but scarce elements of cultural heritage within a contemporary world with an expanding population and changing needs. The management should in fact include a range of elements like cultural landscapes, archaeological sites, old buildings and artefacts that of course exist in an environment where people live, build new constructions and roads, modify the cities and the rural areas as well as create an impact on the cultural resources. For this reason, decisions must be taken in order to strike a balance between the practical and inevitable growth and the protection and preservation of the cultural/archaeological elements (King 2002).

A poor knowledge of the territory or a complete negligence of the local authorities, institutions and operators, has frequently led to the destruction of valuable archaeological remains. There are several cases of severe damages, both archaeological and economic, that could be easily detected and solved. Professionals, developers, constructors, engineers and architects should consider the archaeological factor in their projects.

Furthermore, the introduction of non-destructive investigation techniques along with the control of all the necessary parameters should be taken into consideration. This would help in the management of the urbanization process as well as the preservation of pre-existing elements.

An Overview of Preventive Archaeology

The concept of preventive archaeology changes significantly from country to country and in some cases there are variations on a regional level within the same country.

For example, in the United Kingdom the application of preventive archaeology is ruled by governmental laws since 1990. The results of the researches are usually inserted in an online archive for the documentation of the known and potential remains. In this way, the public has the opportunity to search, consult and access related contents such as maps, aerial images and pictures.

In France, preventive archaeology is known since the 1970s. In fact, the INRAP (Institute National de Recherches Archéologiques Préventives) is in charge of the realization of the National Map on the basis of clear national rules for urban and environmental planning (Pescarin 2009).

In Italy the preservation is entrusted to regions that have the responsibility of the elaboration of the regional Archaeological Maps. It is worth mentioning a project of the region Emilia Romagna for the realization of an online geographical information system, that aimed at widening knowledge and preserving the archaeological patrimony and as a support for the planning activities of the territory: C.A.R.T. (Carta Archeologica del Rischio Territoriale) (Guermandi 2000).

In Cyprus, the archaeological matters are regulated by the national law and controlled by the Department of Antiquities, a body for the management of the archaeological heritage under the Ministry of Communications and Works. In particular the law regulates systematic and rescue excavations as well as archaeological surveys. However there is no standard digital procedure for archiving the acquired data and publishing the information. A recent project of the Department of Antiquites deals with the digitization of the declared ancient monuments and movable artefacts for the construction of a database, but at the moment nothing has been published (CADiP, Cyprus Archaeological Digitization Programme).

This survey highlights the existence of significant differences with cases of excellent practice only in some countries (Bozòki-Ernyeyk 2007). Therefore, instruments that overcome these national or regional differences which are able to classify, digitize and integrate all the information of a territory are highly required. In fact, the integration of documentation techniques with predictive and simulation instruments is of paramount importance for the reconstruction of the ancient landscape and consequently for its better understanding and preservation.

Technological initiatives

Some initiatives dealing with the integration of digital technologies for a better support of archaeological interpretation and decision making are revised below.

These have been mostly developed in England and in the USA and have been applied to various archaeological projects. The Archaeological Recording Kit (http://ark.lparchaeology.com/about/overview) is a web-based 'toolkit' for the collection, storage and dissemination of archaeological data including data-editing, data-creation, data-viewing and data-sharing tools using a web-based front-end. It also provides a framework, an interface and a set of pre-fabricated digital tools for archaeological recording and data.

The Integrated Archaeological Database (IADB) (http://www.iadb.org.uk/) developed at York Archaeological Trust is an online data gathering, storing and recording tool allowing during post excavation for an integrated access of the excavation record. All elements of the excavation archive are being entered into an online database that can be accessed from anywhere by the research team.

Another repository and data archiving service is the Archaeological Data Service of the University of York for ingesting procedures and metadata requirements (http://archaeologydataservice.ac.uk/). The same approach is adopted by the Digital Archaeological Record (tDAR), managed by Digital Antiquity, with the development of an international digital archive and repository for the digital records of archaeological investigations. This ensures the long-term preservation and the access of archaeological data in order to analyse and reuse them, allowing the users to simplify comparative research by using data integration tools (http://www.tdar.org/use/).

Finally, the Center for Digital Archaeology (CoDA) developed digital heritage solutions especially for database applications to make the digital management of primary data and the publication of archaeological data easier by developing tools for handling operations and metadata mapping (http://www.codifi.info/projects/).

The assessment of the reviewed initiatives highlights that the approaches are mainly based on the construction of databases, geo-referenced systems and repositories. They do not take into account the development of different scenarios which depend on technical rules (e.g. the distances to be considered for the construction of a road in the proximity of archaeological remains) as well as the insertion of inputs for preventive answers/simulations about the decisions to take. Moreover, in the case of the analysis and editing of the data, they do not consider standardized solutions, usually tethered instead to the personal choice of an operator.

For these reasons, we propose a technological solution able to manage the constraints input from different professionals and from different aspects (legislation, technical laws, scientific rules, etc.) in order to reflect them into the design process of the evolving infrastructure.

The Project

The everyday contact between various professionals (humanists, archaeologists, IT professionals, graphics and architects) in archaeological problem solving, has brought up the idea of how to deal with the different professional points of view.

The project aims at elaborating an integrated platform for preventive archaeology, urban planning and Cultural Heritage resource management able to receive and handle various constraints input set by different users.

In the field of urban planning, rescue and preventive archaeology there is a lack of managing tools for the different professional constraints. For this reason it is difficult to detect them on the design process of the evolving infrastructures in all their phases. The project wants to overcome the standard digging procedures used only to localize the remains or to elaborate maps. Indeed, the use and improvement of digital integrated techniques will bring a new approach to preventive archaeology and will take into account the relationship with others subjects.

The case study

The archaeological excavation of Agios Georgios Hill in Lefkosia (Cyprus) is used as case study for the design of the integrated platform by simulating and testing the tools

Figure 1. The archaeological excavation of Agios Georgios Hill in Lefkosia (Cyprus).

and the proposed methodology (Fig. 1). During the construction works for the House of Representatives, archaeological traces have been detected. This caused an interruption of the building works and the beginning of archaeological excavations.

The dataset of the case study becomes an important input source for the elaboration of the platform and a useful support in the definition of a pipeline and strategies for the simulation of the possible scenarios of archaeological data management from the planning to the realization phase.

The site is a large settlement of the Hellenistic period with buildings consisting of rectangular rooms of various dimensions and with evidence of workshop activities. Earlier remains of the architectonic structures (Archaic and Classical periods) present later interventions. Moreover, the study of the area has brought up the discovery of some sanctuaries which were related to the workshop activities. The settlement seems to have been abandoned after the middle of the 1st century BC and then re-occupied in the Late Roman period. Some remains inform about the continuation of the industrial activities during the Christian period until the beginning of the Venetian period (Pilides et al. 2010).

STARC in collaboration with the Department of Antiquities has surveyed about 650m^2 of the archaeological site with two different technologies: photogrammetry and laser scanner (Hermon et al. 2010). These two techniques to document the discovered area and their outcomes are the starting point for the investigation and interpretation of the data (Fig. 2).

The three-dimensional acquisition of the area provides the first source of information for the location of archaeological features and the visualization as a whole (modern buildings, roads, protected areas, etc.). Since the site is located within the urban structure of the city it can be considered a good test for the simulation of the different scenarios occurring during the different stages of the excavation: for preventive decision-making, during the excavation activities and as a support for the decision on the post excavation condition.

The possibility of acquiring a digital documentation of the area, placing the known and hypothetical ancient and modern elements, inserting the technical rules to modify and simulate different results depending on the user's purposes, will help to prevent those passages which usually occur in the field in stages too advanced in respect to the decisions to be taken.

In this archaeological excavation, primarily it should have been a tool to digitally acquire all the information about the archaeology of the site and the geological and territorial information (a digital catalogue of known and hypothetical data), and that should have been able to integrate data of the planned new building and especially to elaborate simulations according to any "obstacles". For this reason, the archaeological site of Agios Georgios Hill represents a good example to build a methodology for the development of the integrated system and also a test bed for the experimentation on the field.

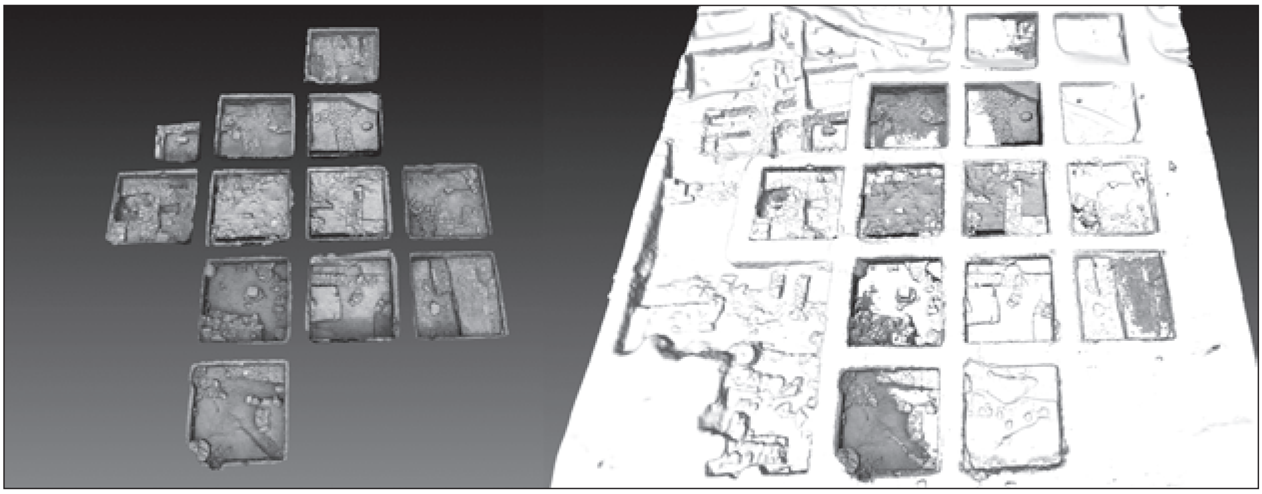

Figure 2. The two acquisition techniques: photogrammetry (left) and the integration between laser scanner and photogrammetry (right).

Integrated Platform Design

The information coming from the environment (cultural, economic, natural, social, historical, morphological, etc.) allows to evaluate the possible interferences between the planning and the context. The integrated platform will document the area, record the situation in all its aspects and reconstruct/simulate both the current and the past situation. The possibility to use different techniques of data acquisition, documentation, interpretation and visualization in one system also allows transforming the qualitative information into quantitative ones and consequently evaluating and proposing the possible alternatives.

The work-flow

The most important thing to consider in the setup of a project and in the elaboration of the work is the methodology which helps us to clearly set all the available or the required elements: the description of the project that we want to realize, the information and the tools at our disposal, the aim of the project (for who or what is it for), the evaluation of mistakes and so on.

The methodology foresees several steps for the elaboration of the work-flow and the final results. The goal of this work is to document an area at the present time, to record the situation in all its aspects, to reconstruct the existing elements and to simulate hypothetical situations in absence of certain knowledge. As a result, this can give us the information needed to reconstruct both the ancient alterations and the new changes. In fact, the landscape as we can observe today is a result of several transformations where diachronic relations describe the changes occurring through time which are useful to propose the correct interpretation of the context (Vassallo and Palombini 2008).

We can list all the steps in four groups:

- Collection

The first step is the gathering of the site information and data required to simulate the different roles in the design process. In fact, the collected material is useful for the implementation of the next steps and to build a database and tables for the analysis of all necessary information: maps, satellite photos, images, technical plans, sources, elaborated data, GIS, GPS data, 3D models, etc.

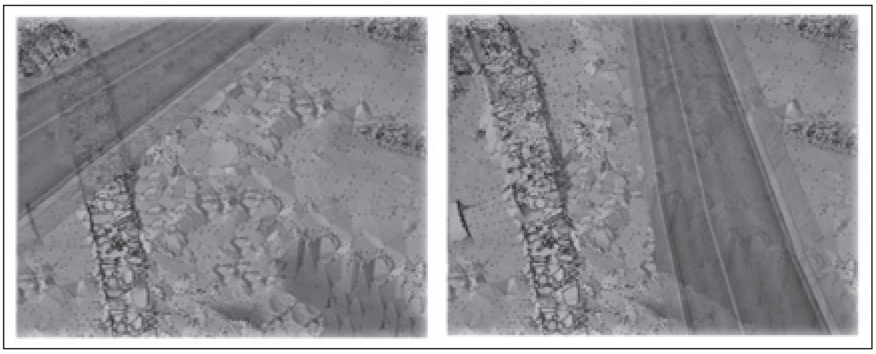

Figure 3. Different simulations on a digital elevation model about the position of a planned road in the vicinity of possible archaeological remains. Also the possibility to visualize all the presences and the different alternatives will help the decision making.

Furthermore, a key aspect is also to define a list of constraints that will form the structure of the system (legislation, development, archaeology, environment, etc.). For example, the possibility to insert rules for the distances in building in an archaeological or protected area, the norms that should be used in a historical centre, the depths in digging in specific terrains or risk zones, the technical regulations to manage an archaeological region, etc.

- Cataloguing

After information gathering, it is necessary to build the databases, 2D and 3D archives and GIS projects in order to manage and use the huge amount of data. To do this, we have to consider also other "constraints": the standards for management and resource description, their interoperability and comparability, the opportunity to refer to thesauri and dictionaries, etc.

- Interpretation

Data on buildings, artefacts and landscape, both ancient and modern, allow connecting the past with the present: viewing at the same digital level all the information from different research fields gives the possibility to start the interpretation of these data in order to provide solutions. The acquired data, converted into compatible digital formats (images, layers, points, tables, etc.), allow launching a series of interpretations and combinations useful for the realization of a complete and multi-level vision.

- Elaboration

The elaboration is not only the final step but a developing process for the 2D and 3D simulations of the several cases, every time different due to differences in the analysed data. In fact, the visual simulation allows verifying the assumptions, contextualizing the information and facilitating the choice of possible behaviour and decision making (Cerato and Vassallo 2009). Therefore, the acquired data, recorded, interpreted and processed converge into a 3D visualization of the entire process, providing different simulations of the studied area (Fig. 3).

Multidisciplinary approach

The analysis of the archaeological landscape and the study of the archaeological risks involve the presence of different professionals' contribution. This characteristic is particularly considered in the project because the main idea is to allow the users carrying out a simulation of reality according to the different constraints entered. The user can insert and manage several data useful for the reconstruction of the reality in all its elements. This allows simulating different roles in the design process and their interaction: archaeologists, architects, urban-planners, engineers, general public and institutions can handle several data and evaluate the solutions, case by case. Every user, according to his/her role can acquire and manage several and different data useful for the documentation and interpretation of the area.

The archaeologists will work with data coming from archaeological excavations, remains, plans, maps, surveys, risk charts, ancient sources, satellite images, aerial photos, geophysical studies, environmental studies (geology, hydrology), cultural heritage legislation, etc. In the same way, architects will deal both with archaeological and technical issues. Engineers and city planners will be able to manage data related to rules and legislation, infrastructures, zoning codes, geophysical and geological studies, always taking into consideration the archaeological data and the risk factor.

Also the involvement of the public should be taken into account. In fact, the public users (citizens, local and governmental authorities) will be able to query plans, maps and data mainly for consultation, conservation and management.

Tools

The use of GIS capabilities with an alpha-numeric database and features for the CAD elaboration is the foundation of the platform. Furthermore, the integration of 3D instruments for the management and elaboration of complex ecosystems is the added value for the comprehension and the interpretation of different overlapping elements. The possibility to add and search through an information retrieval, to look for archive data, to geo-reference data, to digitize maps, aerial images and traces, to search geophysical, geological and botanic data, to measure and draw elements, to elaborate spatial analysis, reconstructions and simulations of different alternatives is the core of the platform.

The collaborative and integrated approach allows different work teams to use multiple tools and disciplines for the interpretation throughout the entire process of urban planning and territory conservation. The presence of the design modelling, interactive dynamic views, geo-coordination and information retrieval in a single platform, give benefits for an increased information quality, an enhancement of the performances and a reduction of time during the entire process. This structure allows to work on multiple levels of detail and to enter and update at any time the information and constraints in the study of the area.

Platform Innovation: from Qualitative to Quantitative Information.

The evaluation of the archaeological risk is a procedure able to verify in advance the transformation of a human intervention on the environmental or archaeological component.

Usually archaeological analyses and therefore preventive archaeology is based on human interpretation. On the basis of the work on the methodology for the evaluation of the archaeological impact we are integrating in the platform a simple system able to mix human interpretations with technical ones. The use of indicators supports the analysis of several elements (Campeol and Pizzinato 2007). The elements are: the analysis and the identification of the archaeological and historical period of the studied area, the quantification of the "importance" factor of an archaeological/historical period; the quantification of the risk level.

The different archaeological/historical periods of a specific case study area are inserted in a table. Every period is characterized by a numerical value: the higher for the older, the lower for the more recent.

The "importance" factor is conceived as a quantitative indicator for an artefact/archaeological object. It is related to different parameters: uniqueness, antiquity, rarity, conservation level and artistic value. Also in this

Uniqueness	Yes 4		No 0	
Rarity	Very rare 4	Rather rare 3	Rare 2	Not rare 1
Antiquity	Archaic and classical period 4	Hellenistic period 3	Christian period 2	Venetian period 1
Conservation	Excellent 4	Good 3	Fair 2	Poor 1
Value	Very good 4	Good 3	Medium 2	Low 1
TOTAL 15				

Table 1. The "importance" analysis of the case-study.

case we can assign a value for each parameter (from 1 to 4) (Table 1).

The results of this evaluation and the sum of all the values of the analysed artefact/remain give the opportunity to draft a range value of the "importance" factor.

The last indicator is of course the risk level: the probability that an intervention could cause on an archaeological area with respect to the "importance" factor of the archaeological period. In a range between 0 and 3, it is possible to define: No Risk = 0 (area without archaeological remains or human traces), Low Risk = 1 (Area with isolated remains and adjacent to archaeological area), Medium Risk = 2 (Area with sporadic remains, contiguous to an archaeological area), High Risk = 3 (Archaeological area). In the end, the evaluation of the Total Risk will come from a range, calculated on the basis of the partial and total risk of each period.

Conclusions

This is still an on-going project, therefore different tests and analysis of the available material as well as the integration of different tools and techniques are being carried out.

The aim of this paper is to describe the methodology that we want to apply for the development of this system in order to overcome the evaluation of the risk depending only on human choice. In fact, also the definition and placement of constraints/rules will give an added value to the risk evaluation process. Distances from an artefact, buffer zones, depth of digging, legislations, etc. will be set on the basis of parameters depending on the quantitative information or "values" of the archaeological risk. As a matter of fact, the proposed solution gives the opportunity to manage in a single environment different subjects and various professional opinions through the definition of rules and constraints.

Finally, the possibility to simulate alternative scenarios and understand, show and test all the possible solutions will contribute to the elaboration of good strategies for decision making processes in preventive archaeology. What is important is that the urban planning decisions will be supported by preventive archaeology (D'Andrea and Guermandi 2008).

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