FIELDWORK REPORTS

Developing an Archaeological GIS for the 'Lost City of the Pyramids': An Interim Report, January-August 2005

Farrah L. Brown
GIS Specialist, Giza Plateau Mapping Project, Ancient Egypt Research Associates

Introduction

Ancient Egypt Research Associates (AERA) is employing geographic information systems (GIS) in an effort to collate and analyse data collected during almost 15 years of work at the Giza Pyramids. GIS will provide great benefits for the analysis and management of this important archaeological and World Heritage site. GIS specialists with AERA's Giza Plateau Mapping Project (GPMP) will disseminate methods and results to the broader GIS and archaeological communities in an effort to share ideas, stimulate discussion, and contribute to a more detailed 'best practice'.

This report summarises the aims and progress of the project and describes methods used to represent archaeological features or contexts in a GIS, a seemingly simple task that neither archaeologists nor GIS professionals have yet undertaken. Currently, GPMP is in the early stages of evaluating its preliminary GIS design by means of a pilot project, and we expect that development and implementation will continue until the end of 2006.

Since 1991, GPMP has conducted excavations at a five-hectare, Fourth Dynasty settlement site about 400m south of the Sphinx at Giza, Egypt (Fig. 1). The excavation of this 4500 year-old city has revealed a view of the infrastructure that supported generations of pyramid construction. It is just one component of a larger study of the Giza Plateau which is guided by the mission of AERA, a non-profit organisation that works to document and contribute to the understanding of the evolution of this ancient cultural landscape (AERA 2001).

Project Aims and Objectives

Arising from the needs of North American cultural resource management for mapping, regional analysis and predictive modelling, GIS studies in archaeology have been common since the early 1980s (Allen et al. 1990; Brown and Rubin 1982 as cited in Kvamme 1995; Lock and Stancic 1995; Westcott and Brandon 2000). Intra-site GIS studies in archaeology, however, were not widely performed until recently (Lock 2000; Wheatley and Gillings 2002).

While archaeologists and GIS professionals continue to work towards a standard GIS data model for archaeology, development is still in its early stages (Craig and Aldenderfer 2003) and mainly limited to regional-level management and analysis (Environmental Systems Research Institute (ESRI) 2002). Consequently, the field of archaeological GIS still lacks proven methods for representing archaeological features in a GIS as specific data types: as vector data (*points*, *lines*, and *polygons)*, as continuous data (*rasters)*, or as a combination of both types (to which Burrough and McDonnell 1998 provide an excellent introduction).

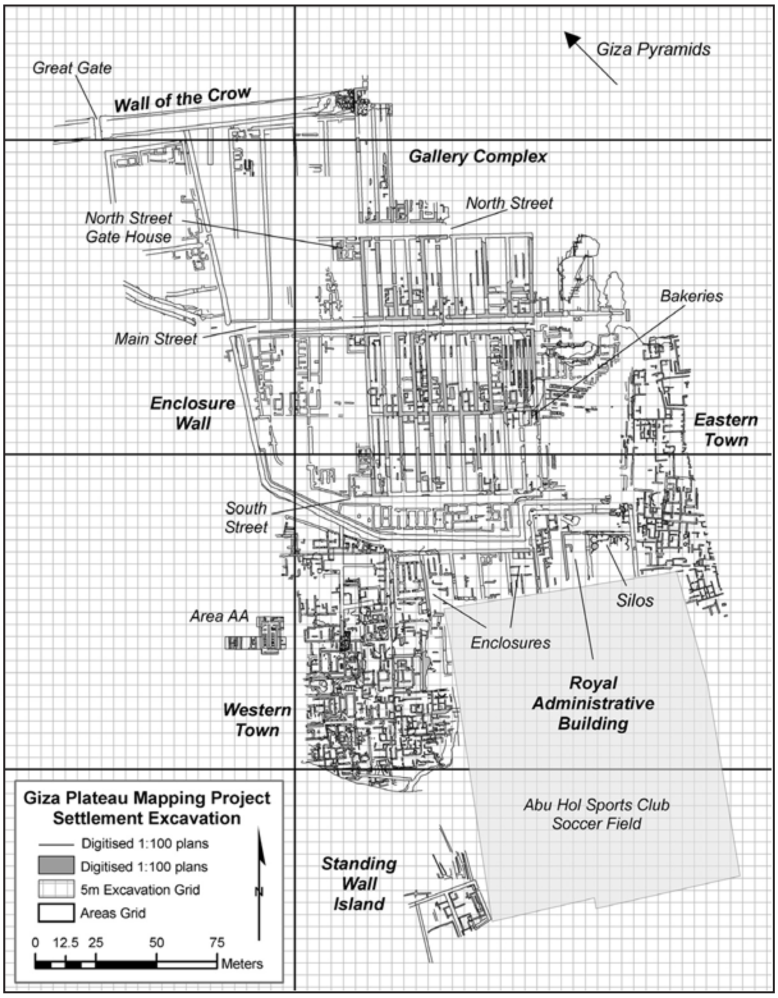

Figure 1. Plan showing the digitised area of GPMP excavations at Giza.

GPMP's GIS project provides a unique opportunity to design and test a feature-level data model that suits our needs but can also be adapted for use with other excavations. With the primary method of input being the digitising of thousands of drawings, accurate and efficient spatial representation is essential. The Arts and Humanities Data Service's (AHDS) *GIS Guide to Good Practice* (Gillings and Wise 1998) is a valuable resource in this effort, but does not outline specific methods for the initial design of a complex excavation GIS.

Generously funded by the Charles Simonyi Fund for Arts and Sciences, GPMP's GIS project began in January 2005. It is supervised by Ana Tavares, John Nolan, and Dr Mark Lehner. The specific aims of this project are to:

- Maintain the integrity of all data while representing it in a manner that allows for efficient storage and access as well as accurate analysis and reporting.
- Create new data while integrating and utilising the multitude of existing data.
- Promote data consistency and facilitate accurate data collection and entry.
- Provide easy access to data sources and user-friendly mapping tools for team members.
- Visualise the archaeology and modern landscape of the Giza Plateau in 2D and 3D.
- Explore distributions and densities of specific artefact, feature and architectural types.
- Document and manage environmental impacts and modern-day threats to the site.

At the start of the project, Environmental Systems Research Institute, Inc. (ESRI) donated three copies of its popular GIS software, thus promoting current work towards achievement of the following objectives:

1. Designing a preliminary data model that maintains data integrity, accommodates data collected to varying standards and permits the required GIS functionality.
2. Editing and loading archived data for use in a dynamic basemap upon which other data can be layered.

Methods

The Preliminary GIS Design

The GIS design process consists of three main stages that are similar to those of modelling other phenomena using computers: conceptual, logical and physical designs (Arctur and Zeiler 2004: 8-9). GIS fieldwork at Giza during the spring of 2005 focused on the 'conceptual' design, or first stage. Understanding how GPMP archaeologists collect, document and organise their data is crucial, as this knowledge provides the foundation for a well-planned and functional product. We interviewed team members about their data collection methods, workflows and goals, and asked them to enumerate the key thematic layers to be included in the GIS.

The GIS team then chose spatial representations for each of the layers and grouped them into datasets, with consideration of goals and required functionality. Some representations are straightforward: locations of objects, elevations and other survey points are stored as *point* feature classes. The 1m contour data are stored in a *line* class, while survey and excavation grids are stored in *polygon*, or area, feature classes. Other data representations are more complex, however, and finding a balance between preserving detail and excluding unnecessary elements can be difficult.

Another complication is the need to impose consistency on data collected by many different people over many years. Just as mapping styles differ with each excavator, standards have also changed several times since the start of excavations. Currently, excavators are encouraged to use single-context planning and the Museum of London Archaeological Service (MoLAS) drawing conventions (MoLAS 1994), and we believe that these conventions provide a good standard for the future. We have therefore incorporated these conventions into the GIS design and are using them during data entry whenever possible.

GIS team members will use on-screen, or 'heads-up', digitising methods (Burrough and McDonnell 1998: 88) on scanned field drawings, which will be geo-referenced and stored in ArcGIS *raster catalogs*. In our initial GIS design, one can potentially use up to five separate feature classes from the 'ArchaeologicalFeatures' dataset (Fig. 2) to describe the characteristics of one field drawing. Within this dataset, there are *point* classes for designations of elevations and objects, and a *polygon* feature class with which to outline the boundary of each feature. A *line* class exists for describing a feature's characteristics, including changes of slope, vertical edges, and oblique cuts, as well as details about the extent of the feature. Finally, an additional *polygon* feature class is available for representation of other characteristics that have area.

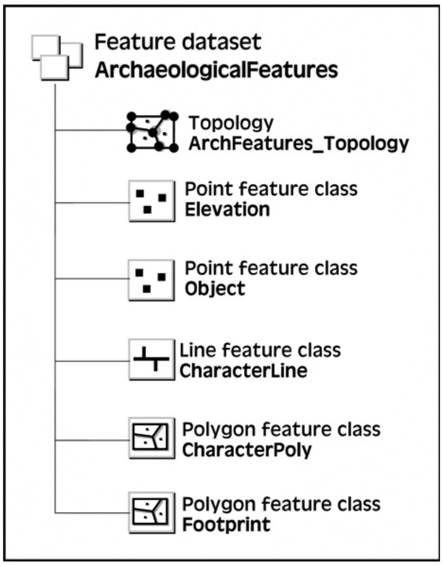

Figure 2. Structure of the dataset in which spatial data describing archaeological features will be stored.

We are also completing tasks associated with the second stage of GIS development, or the 'logical' design. We have defined the structures and relationships of attribute tables and the spatial properties of datasets that we outlined in the conceptual stage (Arctur and Zeiler 2004: 8-9). Additionally, we are placing data entry restrictions on tables and establishing rules within the software to govern the placement of spatial objects during digitising.

The third stage, or 'physical' design, involves implementation, review, documentation and maintenance of the data model (Arctur and Zeiler 2004: 8-9). We are planning a pilot project, in which we will digitise various datasets from several excavation areas. This process of loading data into the model will reveal the strengths and weaknesses of the design, and we will revise it accordingly. Once the design is finalised, standardised workflows within GPMP will help maintain data, and documentation will be made available for use by other archaeologists.

The Basemap

Efforts to create a dynamic basemap have centred on the integration of three critical GPMP datasets. One dataset contains 1m contours that were digitised from a 1978 series of 1:5000 topographic maps of the greater Cairo area. Another set, depicting the plateau and its architectural components, was created during a 3D modelling exercise undertaken by GPMP in 1991 and is stored in a format specific to computer-aided design (CAD) software (Sanders and Sanders 2001). The third dataset is a series of 1:100 paper plans that document the site as it was initially exposed after removal of 34,000 cubic meters of overburden during the 1999/2000 season (Lehner 2000).

We derived a surface of the Giza Plateau from the first two of these datasets and stored it in the GIS as a triangulated irregular network (TIN). Although this surface contains elements collected at different times, it provides the basis for a complete GIS basemap. The scanned and digitized 1:100 plans and other such data layers can then be draped over the TIN and directed to adopt its height values, creating an almost 3D visualisation of the landscape (Fig. 3).

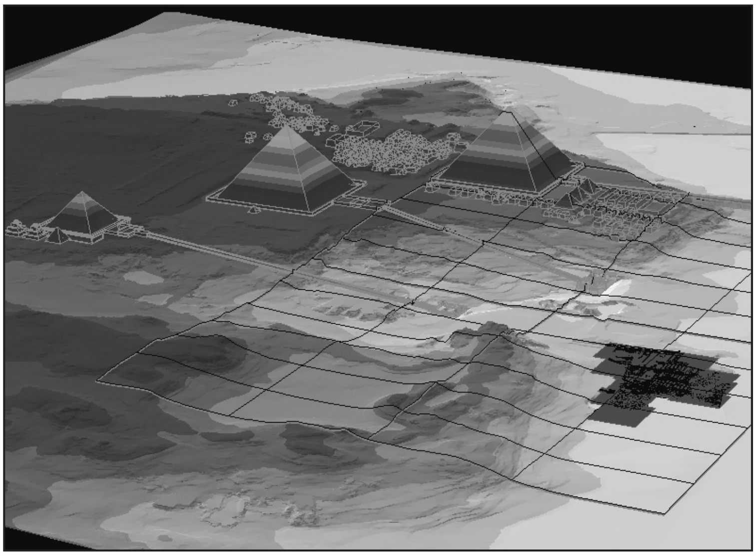

Figure 3. An initial GPMP basemap, consisting of the TIN surface, a survey grid, and the digitised 1:100 plans.

Discussion

We have made considerable progress in the initial months of this project. Our efforts to understand and accurately represent the GPMP dataset, as well as to construct a GIS basemap for the excavation, have been successful thus far. Additionally, we now have in place a preliminary method for representing archaeological features that satisfies our mapping and analysis needs. Furthermore, this method and the design of the 'ArchaeologicalFeatures' dataset seem to overcome many problems that archaeologists face when attempting to transfer field drawings to a GIS format, and it may provide a starting point for other archaeologists aiming to implement an intra-site GIS project.

By utilising multiple spatial representations, the initial design allows for GIS functionality since it captures essential archaeological information recorded on the drawing. While not all GPMP field drawings from the last 15 years use MoLAS mapping conventions, the structure of the 'ArchaeologicalFeatures' dataset attempts to represent all data using MoLAS symbology.

Sharing ideas about possible methods of representation – such as the one described here, and other issues specific to archaeological GIS – is key to the success of this project and to the establishment of more detailed guidelines for the archaeological community. Relationships with other GIS professionals are also important for discussion of similar datasets and designs.

Conclusion

This year marks AERA's entry into the realm of archaeological exploration aided by GIS technology, and the potential of the project continues to grow. GIS is a powerful tool that will open doors to an entirely new aspect of analysis for the activities at Giza. We are currently focusing efforts on the data model design and the upcoming pilot project, as implementation of an effective model will provide the basis for accurate spatial analysis. Efforts in 2006 will involve completion of the pilot project and refinement of the design, integration of multiple datasets, and further facilitation of accurate data collection and entry. We are also currently evaluating a proposal that may improve data access and provide basic online mapping tools for team members.

Acknowledgements

I would like to thank the Charles Simonyi Fund for Arts and Sciences, Dr Mark Lehner and ESRI. This project would not be possible without their generous support and assistance. I am also grateful to Ana Tavares, Brian Hunt and John Nolan for their encouragement and guidance. Fellow GIS team members Rebekah Miracle, Emmy Malak and Luke Lehner, as well as many GPMP archaeologists and specialists, have also kindly contributed many hours to this project. Thanks also to Stuart Eve for his input during numerous discussions about data representation.

References

Allen, K. M. S., Green, S. W. and Zubrow, E. B. W. (eds.) 1990. *Interpreting Space: GIS and Archaeology*. London: Taylor and Francis.

Ancient Egypt Research Associates, Inc. (AERA). 2001. *Introducing AERA*. [http://www.fas.harvard.edu/~aera/Introduce_AERA.html] [Accessed August 2005].

Arctur, D. and Zeiler, M. 2004. *Designing Geodatabases: Case Studies in GIS Data Modeling*. Redlands: ESRI.

Burrough, P. A. and McDonnell, R. A. 1998. *Principles of Geographic Information Systems*. Oxford: Oxford University Press.

Craig, N. and Aldenderfer, M. 2003. Preliminary Stages in the Development of a Real-Time Digital Data Recording System for Archaeological Excavation Using ArcView GIS 3.1. *Journal of GIS in Archaeology* 1, 11-22.

Environmental Systems Research Institute, Inc. (ESRI). 2002. *Historic Preservation and Archaeology Data Model.* [http://support.esri.com/index.cfm?fa=downloads.dataModels.filteredGateway&dmid=29] [Accessed July 2005].

Gillings, M. and Wise, A. L. (eds.) 1998. *GIS: A Guide to Good Practice*. Oxford: Oxbow Books. [http://ads.ahds.ac.uk/project/goodguides/gis/index.html] [Accessed August 2005].

Kvamme, K. L. 1995. A View From Across the Water: the North American Experience in Archaeological GIS, in Lock, G. and Stancic, Z. (eds.) *Archaeology and Geographic Information Systems: A European Perspective*. London: Taylor and Francis, 1-14.

Lehner, M. 2000. The First Year of the Millennium Project: Unveiling a Royal Plan. *Aeragram* 4(1), 1-2, 6-7.

Lock, G. (ed.) 2000. *Beyond the Map: Archaeology and Spatial Technologies.* Amsterdam: IOS Press.

Lock, G. and Stancic, Z. (eds.) 1995. *Archaeology and Geographic Information Systems: A European Perspective*. London: Taylor and Francis.

Museum of London Archaeological Service (MoLAS). 1994. *Archaeological Site Manual*. London: MoLAS.

Sanders, J. C. and Sanders, P. M. 2001. *Constructing the Giza Plateau Computer Model: 1990-1995*. [http://oi.uchicago.edu/OI/DEPT/COMP/GIZ/MODEL/Giza_Model.html] [Accessed August 2005].

Westcott, K. L. and Brandon, R. J. 2000. *Practical Applications of GIS for Archaeologists*. London: Taylor and Francis.

Wheatley, D. and Gillings, M. 2002. *Spatial Technology and Archaeology: The Archaeological Applications of GIS*. New York: Taylor and Francis.