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Remote Inventory of Greek Vernacular Architecture: Online Capture of Spatial Information

Abstract: Since 1990, the Minnesota Archaeological Researches in the Western Peloponnese (MARWP) has undertaken archaeological investigations throughout the southern and western edge of the Peloponnese of Greece. One of the focuses of this work, termed the Morea Project, involved a survey of vernacular architecture dating from the period of Frankish occupation in the 13th century AD to the present. This project's goal was to discover, document, and study previously unrecorded buildings and towns before they are destroyed by man and nature. In 2004, MARWP began development of an online GIS to speed the distribution of data collected during the course of the project. Tools for the remote collection of new attribute and spatial information were developed as part of this application. This paper presents the process and results of the development of MARWP's online GIS system.

Introduction

In 1990, the Minnesota Archaeological Researches in the Western Peloponnese (MARWP) began three separate but concurrent archaeological investigations in the Western Peloponnese of Greece: the Pylos, Messene and Morea projects. Together, these projects spanned a large geographic area (*Fig. 1*) and a broad chronological range, extending from the Bronze Age through the Modern periods. The Pylos project involved the re-excavation and examination of architecture and finds from the Bronze Age palace of Nestor, located in the southwest Peloponnese (Cooper forthcoming). A second project, undertaken at the site of ancient Messene, involved the excavation and inventory of material associated with a temple-like building that formed part of the stadium complex. The third project and the focus of this paper was the Morea project, a survey of vernacular architecture in the northwest Peloponnese from the period of Frankish occupation in the 13th century A.D. to the present. This project's goal was to discover, document and study previously unrecorded buildings and towns before they are destroyed by human activity and environmental processes.

Survey Methodology

The Morea project was conceived as an intensive census of vernacular architecture and the survey's broad geographic extent encouraged the use of both

traditional and innovative survey methodologies. MARWP field crews identified structures of interest through terrestrial survey and remote site prospection, in some cases using multispectral imagery to pinpoint probable sites hidden on remote mountainsides (BRENNINGMEYER / COOPER / VERFENSTEIN 1998; COOPER 2002, 26–28). Sites and individual structures were catalogued in the field, surveyed with Trimble Pathfinder GPS rovers and entered into the project's database system. Each record included detailed information that uniquely described a building's architectural characteristics. Lintels (*Fig. 2*) were catalogued with stylistic characteristics and decorative details noted. Quoins likewise were examined and characterized by type with the placement of unusual decorative elements (*Fig. 3*) similarly noted. Date stones (*Fig. 4*) were catalogued to determine the date of construction or structural renovation. Taken together, the information collected for each building's façade served as a signature for not only the building but also those involved in its construction. As F.A. Cooper has noted, "itinerant masons brought to the construction site their own, pre-fashioned centering systems for installation of relieving arches above doors and windows" (COOPER 2002, 41). Lintels, door casements and quoins thereby conform to the mason's individual style. The detailed architectural data compiled by MARWP researchers provided information about the geographic distribution of masonry styles and the movement of itinerant craftsmen across the countryside, which continues to be a topic of interest to members of the project.

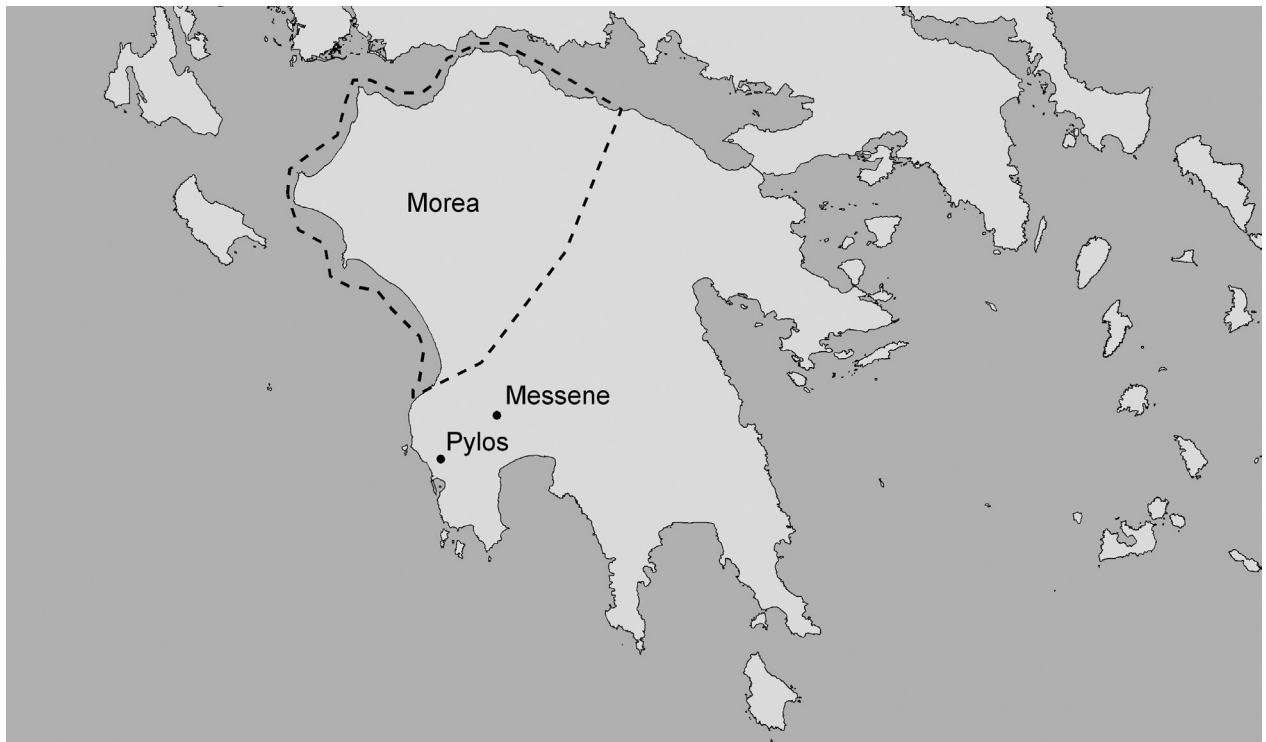


Fig. 1. Map of the Peloponnese showing the three MARWP project areas (Courtesy Minnesota Archaeological Researches in the Western Peloponnese).

Architectural details were collected using standardized field sheets like that illustrated in Fig. 5. Roof shape, tile type, quoin and lintel configuration were captured along with information pertaining to the date and history of the structure. Scaled drawings and photographs accompanied the field sheets providing a hard copy source of data for more than 2,500 buildings. The standardized format enabled the efficient translation of field notes to coded database entries.

From the early stages of the project, AutoCAD was used as both a drafting aid and repository for all geographic data. Site locations collected during the Morea project were compiled in the project database and illustrated graphically within AutoCAD. UTM coordinates marking building corners and roads (Fig. 6) also were collected with Trimble Pathfinder rovers and downloaded into AutoCAD. These points were later converted to points, lines and polygons and form the core of the project's GIS database. CAD templates also were used to speed the illustration of building facades. Many of the inked drawings created during the course of the survey and later incorporated into the project publication were based on these templates.

Much of the material catalogued in the course of MARWP's investigations was published in 2002. The published text provided coordinates, illustrations and descriptions of features identified during the project. However, not all of the buildings and information collected during the project could be included in the final manuscript. A significant portion of the compiled spatial and attribute data remained unpublished in the MARWP archives and database.

Development of MARWP's Online GIS System

In 2004, a decision was made to provide access to the complete corpus of materials in the project archive. Given the geographic nature of the data and our interest in making the material available to MARWP researchers and other interested scholars dispersed throughout the globe, an internet based GIS solution seemed appropriate. The intent was to provide a forum for both data delivery and analysis. The development of the MARWP GIS had specific goals from its inception. While it was important to distribute our data to interested scholars we



Fig. 2. Decorative Lintel (Courtesy Minnesota Archaeological Researches in the Western Peloponnese).



Fig. 3. Quoin catalogued in the Morea survey (Courtesy Minnesota Archaeological Researches in the Western Peloponnese).

also saw the project as an opportunity to develop a system that could serve as a template for other archaeological investigations. Ideally, this template could be used by SHPO or other researchers with comparable needs. Since MARWP's research was ongoing, we also felt that it was important to provide colleagues with the ability to capture and attribute new sites from remote locations. Rather than a static catalogue for data display and retrieval, the system was designed with data capture tools that would allow scholars to quickly digitize features onscreen with associated attributes entered through standardized web forms. The goal was to create a flexible system for remote data capture as well as display where project members in the field could upload new data and make this immediately available to colleagues working in remote or offsite locations.

Equipment constraints encouraged the maintenance of a small and efficient site profile. The original site, launched in January 2005 relied on MARWP's old but faithful workhorse server, which was built from parts acquired in the mid-late 1990's: pentium II 233 processor, less than 500 mb RAM, 5 Gb hard drive, running Redhat Linux. This server proved a good testing ground as any inefficiencies in our code were immediately apparent in the site's performance. As with most archaeological projects, cost was an important consideration and a conscious decision was made to develop the site using OpenSource (free) software. Selecting OpenSource software served two purposes. First, it provided a way to minimize our investment in the development of the application but even more importantly we believed that it would encourage interested scholars

or developers to use and continue development of the application.

Phase I: Initial Development and Implementation

Version I of the Morea GIS was developed using the University of Minnesota's MapServer application with a simple JavaScript interface managing the interaction between the user and the web based application (Fig. 7). This approach met many but not all of the needs of our project. MapServer is an OpenSource internet map server that provides web based access to geospatial data. GIS data, stored on a remote server, is rendered according to parameters set by the developers within a single or series of text files (termed mapfiles within the MapServer application). These rendered images are then embedded within the project's web pages and served to the user through a web server. We were drawn to MapServer because of the cost and its performance when tested against other proprietary systems.

As mentioned above, much of our geographic data was held in AutoCAD. In the early stages of the project, AutoCAD provided one of the few platforms that supported the quick and relatively simple download of GPS data to a graphical format. AutoCAD also avoided some of the issues associated with coordinate precision and rounding that were found in other early file formats. These CAD files, however, were not directly connected with the attributes that described each location and it took some effort to clean and convert this data to a format that could be used by MapServer. We converted the CAD data to shapefile format using a combination of AutoCAD built in conversion utilities and



Fig. 4. Date stone (Courtesy Minnesota Archaeological Researches in the Western Peloponnese).

Safe Software’s Feature Manipulation Engine (FME) which gave us complete control over the conversion process. House corner points were converted to polygons that maintained the orientation specified by either the GPS coordinates or the project database. Flat files in dbase format held the full range of attributes associated with each house, village or Frankish period site.

While shapefiles are a ubiquitous file format and are supported by most GIS based applications including MapServer, we did encounter some performance issues and database related constraints. There were limited options for updating the shapefiles remotely. While it was possible to develop an approach that used the shapelib library (<http://shapelib.maptools.org/>) to remotely write or update the files, this was beyond the scope of our project. The dbase format also posed some problems in our initial design. Our shapefiles held data associated with each structure in a large flat file that caused problems for our PHP based parser, which could only handle a limited number of columns within a file.

Finally, from the perspective of site design and usability, the initial design of our internet GIS did not meet the needs of our project plan. Query results were extracted directly from the database and fed to a small window on the left side of the web page. Users were forced to scroll through more than 70 columns of returned results. Worse yet, the coded records were incomprehensible to all but those project members involved in the database design or GIS implementation. A scholar wishing to examine the distribution of a set of architectural features across the landscape would require a list of keys to the data codes to interpret or query the database.

VILLAGE: _____ POSE: _____ ROH: _____ Frame: _____ DATE: _____ initials: _____
 Informant: _____ Year built/Age: _____
 Stonemason from: _____ Stone from: _____

Abandoned: Y or N _____
 Condition: _____
 Age/Date: _____
 Code for Bldg Material: _____
 Roof: _____ Tiles: _____ Hand/Indust _____
 Stairs: _____ f: _____
 House corners: _____
 Total quoins on 1 corner: _____
 Quoins per meter: _____
 Nr. of storeys: _____
 1st storey use: Apo/other: _____
 2nd storey use: Res/other: _____
 Facade length: _____ m _____ N
 Side length: _____ m _____ W _____ E _____ S
 Azimuth of Facade: _____ W _____ E _____ S _____ N
 Slope of Ground: _____ m _____ W _____ E _____ S _____ N
 Azimuth: _____ m _____ W _____ E _____ S _____ N
 Rate: _____
 Chimney: _____ terra cotta _____
 _____ cones _____
 _____ wall bulge _____

D1: S: _____ F: _____ H: _____
 D2: S: _____ F: _____ H: _____
 D3: S: _____ F: _____ H: _____
 W1: S: _____ F: _____ H: _____
 W2: S: _____ F: _____ H: _____
 W3: S: _____ F: _____ H: _____

apothek(e): # _____ Att to house _____ Bake Oven: exposed _____
 Azimuth: _____ apothek(e) _____ enclosed _____
 Distance: _____ free-standing _____ under shed _____ free-standing wall _____

1	REVEAL	CODES	HEADERS
2	A QUOIN →	STONE 11	Lintel A
3	COURSED code B	WOOD 12	False B a
	PLAIN code C	TERRA 13	Arch b
	SASHED code D	PLASTER 14	Arch C
		METAL 15	a
		CEMENT 16	b
		MIXED 17	c
		ADOB 18	d
		OPEN 19	e
			f
			g
			h
			i
			j
			2-P1
			P-B
			Tympanum T
			a
			b

Fig. 5. Standard MARWP field sheet (Courtesy Minnesota Archaeological Researches in the Western Peloponnese).

Phase II: Developing an Effective Open-Source Data Collection and Retrieval System

We took the lessons learned during the first phase of development and redesigned our interface early in 2005 to better meet the goals set out at the project’s inception. The second version of the Morea GIS used a combination of JavaScript, PHP/Mapscript and PostGIS, a spatial database extension that sits on top of PostgreSQL, an opensource relational database system (<http://www.postgresql.org/>) (Fig. 8). This involved some significant rewrites to the site but provided options and additional functionality that was not possible with the original JavaScript interface. The shapefiles used in the previous version of the site were imported to PostGIS and indexed to improve performance. This enhanced not only our access to the database tables and individual records but also to the underlying structure of the geographic data, which was also stored in PostgreSQL. PostGIS provides its own robust GIS functions that work directly on the data. Using these functions rather than

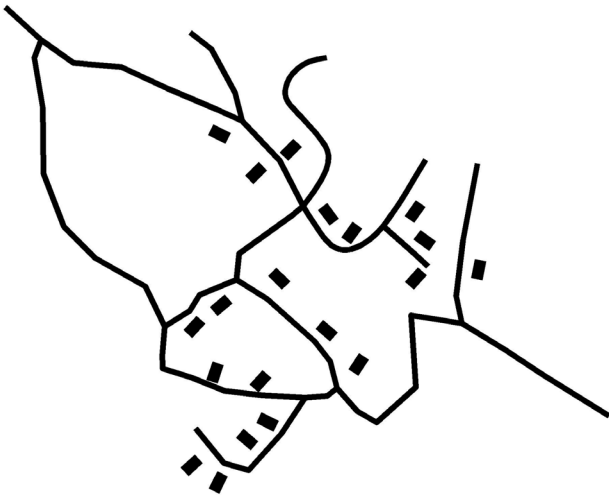


Fig. 6. Screen capture of geographic data maintained in AutoCAD format (Courtesy Minnesota Archaeological Researches in the Western Peloponnese).

those embedded within MapServer or MapScript improved the application's responsiveness and provided enhanced data analysis possibilities.

In addition to revising the underlying data structure, we made several modifications to the site design. The new site separated the geographic and database components into separate tabs with each tab activating a CSS container sized to take advantage of the space available in the browser window. A map tab provides tools and a large canvas for spatial queries, map display and digitization. A report tab offers a large canvas for the display of formatted data and multimedia elements. Since each tab holds data within a separate CSS container, it is possible to toggle between map and data views quickly without refreshing the data in either view. This new design encouraged us to rethink our approach to data navigation and usability. The current application provides an indexed list of selected features in a pullout located on the right hand side of the screen. Users can select features from this list and view additional attributes that appear in the dedicated report tab (Fig. 9). The application translates the coded entries to easily understandable terms and formats the output in a structured report. Data describing villages and individual structures may be selected together and displayed. The report tab presents additional multimedia elements to the user including inked drawings of the building elevations. To improve legibility, coded attributes were replaced with images that provide graphic translations of the coded data values. Images of flat, combination or curved tiles replace the coded values that were

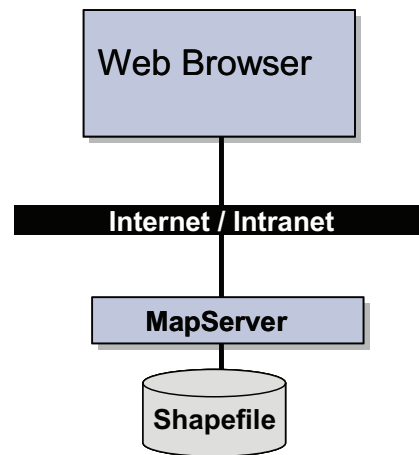


Fig. 7. Diagram illustrating the design of the initial Morea GIS application (Courtesy Minnesota Archaeological Researches in the Western Peloponnese).

used in the original interface. Lintel configurations are also translated to images that provide simple guides for the user.

One of the goals from the beginning of the project was to enable MARWP researchers or other individuals to continue the inventory of vernacular buildings remotely through a simple web browser. We believed that such a tool would benefit our project and provide a toolset that could be used in a variety of research applications beyond the Morea survey. Two applications provided capabilities that were similar to what we desired but were not implement-

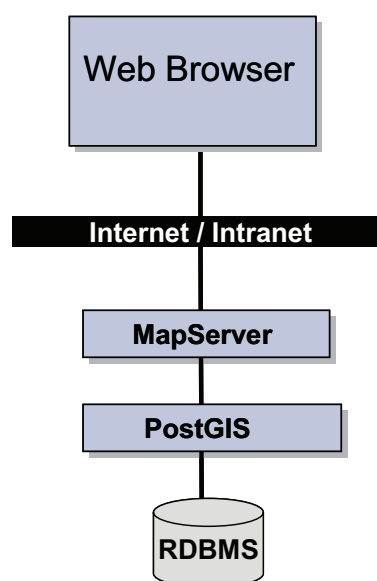


Fig. 8. Diagram illustrating the design of the second Morea GIS application (Courtesy Minnesota Archaeological Researches in the Western Peloponnese).

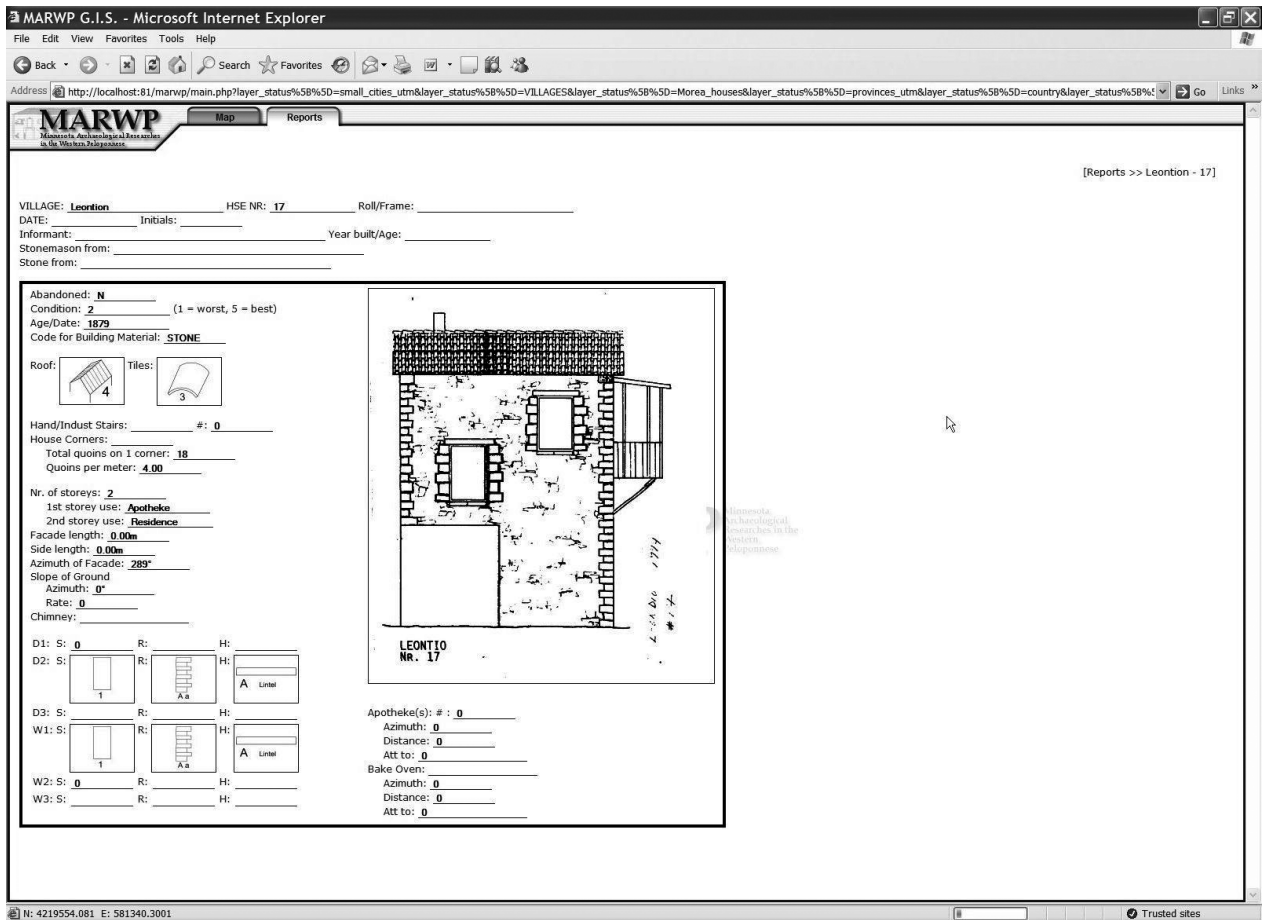


Fig. 9. Dedicated report tab enabling users to toggle between map and report view without refreshing the web page (Courtesy Minnesota Archaeological Researches in the Western Peloponnese).

ed due to cost and development preferences. ESRI's ArcGIS Server provides limited editing capabilities through a web browser and there are some efforts to apply this application to SHPO needs. Unfortunately, the cost of this application prohibited its use by MARWP. GeoServer (<http://geoserver.org/>) is an OpenSource WMS and WFS-T server that provides attribute and geometry update capabilities, but we were well into the development of the MARWP GIS when we became aware of this application and chose to continue our efforts rather than begin development on a new platform. Our redlining or remote inventory tool used Walter Zorn's JavaScript Vector Graphics Library (http://www.walterzorn.com/jsgraphics/jsgraphics_e.htm). Zorn's library provides functions for drawing a variety of geometric shapes and proved to be very efficient. The redlining tools are password protected but once accessed users have the option of digitizing a point, line, or polygon feature. In the case of polygons, the points digitized on the screen are concatenated into a list

with the first and last points appended to close the polygon. The user is then prompted to complete the data collection process by filling out a standard web form with drop down menus and text boxes that guide the user in the completion of the form. A date stamp is added to each record to capture the date that the feature was uploaded to the system. The coordinates, attributes and date stamp are concatenated and placed within an SQL statement that is sent to the server. A PHP script on the server submits the SQL commands to the project database which creates a record in a review table. The uploaded data is immediately available to anyone accessing the MARWP website. But, the uploaded data must be reviewed and approved before it is accepted and appended to the primary project database tables. This process limits the possibility of corrupting project tables through accidental or intentional errors.

The development of the Morea GIS expanded our ability to present the results of the survey as well as provide access to a variety of images of the Pelop-

ponnese that were collected during the course of the Pylos, Messene and morea investigations. The images include Landsat mosaics of the Peloponnese, pan sharpened Quickbird mosaics of ancient Messene and the Palace of Nestor as well as aerial photographs flown during the final weeks of excavation at the Palace of Nestor. We tested a variety of techniques for delivering large datasets through the Morea GIS without significantly impacting the speed of the application. Our Mapserver application ran most effectively when serving GeoTiff mosaics. GeoTiffs are constrained to a 4 Gb file size which was large enough for our data. Images were pre-processed using the "gdaladdo" utility in the Geospatial Data Abstraction Library (GDAL <http://www.gdal.org/>). This utility built multiple internal overviews into each image, increasing the efficiency of the application at a variety of scales. This enabled us to serve very large datasets, including a 1.5 Gb Landsat 7 Mosaic of the Peloponnese, with very little change in the responsiveness of the application. The Morea GIS allowed us to quickly make the full range of data collected during the course of our investigations available to the general public.

The next phase of development involves building on the application described in this presentation. We are currently developing additional options for querying the database and integrating the spatial query functions of PostGIS within the application. Our next goal is to integrate the Morea GIS application with object catalogue and reconstruction software used to query and reconstruct fresco fragments in the Palace of Nestor investigations. This will provide an embedded module for manipulating and examining artifacts on-screen which are tied to their spatial location within the GIS application. The Morea project shares the same needs as many environmental, architectural and archaeological surveys and the design and functionality used in this project can be extended to other areas of research. The hope is that this project will serve as a template for future development of catalogues of archaeological and historical materials.

References

- BRENNINGMEYER / COOPER / VERFENSTEIN 1998
 T. BRENNINGMEYER / F. COOPER / C. D. VERFENSTEIN, Satellites, Silicon, and Stone: Spatial Information and Greek Archaeology. *Geo-Info Systems Magazine*, 1998, 20–28.
- COOPER 2002
 F. A. COOPER, Houses of the Morea (Athens 2002).
- COOPER forthcoming
 F. A. COOPER, The Minnesota Pylos Project: Investigations and Results, 1990–98. In: F. A. COOPER / D. FORTENBERRY (eds.), *The Minnesota Pylos Project 1, 1990–1998* (BAR forthcoming).

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