

Arches: An Open Source GIS for the Inventory and Management of Immovable Cultural Heritage

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Abstract. The Getty Conservation Institute (GCI) and World Monuments Fund (WMF) are collaboratively developing for the international heritage field an open source, web-based GIS purpose-built for inventorying and managing immovable cultural heritage. GCI-WMF will release an “alpha” version of the Arches system as an open source project in December 2012, and a more advanced “beta” version in spring 2013. In parallel to its development for the heritage field, Arches is being customized for use by the City of Los Angeles, USA. It incorporates widely adopted standards (for heritage inventories, heritage data, and information technology) so the core system will offer a solid foundation that heritage institutions may customize to meet their needs. As an open source system, Arches will be available at no cost, and will allow adopters to share resources to enhance it in mutually beneficial ways as well as maintain it.

Keywords: heritage management, recording and documentation, inventories, geographic information systems (GIS), open source software.

1 Introduction

For authorities tasked with managing numerous heritage assets, whether at national, regional, local, or site scales, the most essential tool for decision making is an inventory. Inventories have traditionally informed authorities, scholars, and the public of essential information about cultural assets, such as their location and spatial extent, their association with historical periods, cultures, and events, and whether they incorporate particular architectural styles and building technologies. Inventories allow for comparison of numerous heritage sites, which aids in classification, in comparison of authenticity and integrity of extant historic fabric, and in significance assessment. Such assessments can help in prioritizing management interventions. In many jurisdictions legislation ties inventories to legal protection. Inventories are also especially needed for heritage protection in cases of disasters and armed conflict.

Many heritage authorities struggle to meet the demands of undertaking comprehensive inventories, as well as of establishing and sustaining appropriate heritage information systems. This paper presents the collaborative work of the Getty Conservation Institute (GCI) and World Monuments Fund (WMF) to address this challenge by developing an open source, web-based geographic information system (GIS) purpose-built for inventorying and managing immovable heritage.

2 Project History

In June 2010, the GCI and WMF completed development of the Middle Eastern Geodatabase for Antiquities (MEGA)–Jordan, an open source, web-based, Arabic-English GIS designed to serve as an archaeological site inventory and management system for the Jordanian Department of Antiquities (DoA) [1]. The DoA deployed MEGA–Jordan kingdomwide in December 2010. The DoA has allowed public access to the system for viewing and searching purposes at: www.megajordan.org.¹

The screenshot displays the MEGA-Jordan web interface. At the top, the browser address bar shows megajordan.org. The main content area features a satellite map of Amman, Jordan, with a search box containing 'Cita'. A search results panel shows 'AMMAN / CITADEL' with details: 'JADIS: 2315002, Amman Citadel' and 'MEGA-J #: 2682'. A sidebar on the right lists various tasks such as 'Add a New Site', 'Add a New Site Element', 'Print Site, Site Element and Monitoring Cards', 'Add a Reference', 'User Administration', 'Director Reporting', 'Upload MEGA file', and 'Review MEGA file'. Below the map, a detailed site information panel for 'AMMAN / CITADEL' is visible, including the MEGA-J Number (2682), location (Jordan > AMMAN > Al-Jam'ah), and a list of threats and disturbances. The bottom of the interface shows a navigation menu with options like 'Reports', 'Jordan > AMMAN > Al-Jam'ah > AMMAN / CITADEL', and 'Monitoring Events'.

Fig. 1. The MEGA-Jordan web user interface displaying data for a site monitoring event and a site's recorded boundary and site elements. (© 2012 Google)

¹ To ensure data security, most of MEGA-Jordan's advanced features are not publicly accessible. The system's full functionality may be viewed in an overview video on the megajordan.org homepage or at: www.getty.edu/conservation/field_projects/jordan/mega_overview.html

In April 2011, GCI-WMF made available a prototype of MEGA-Iraq for archaeological sites to the Iraq State Board of Antiquities and Heritage (SBAH). This project has been delayed due to administrative changes in Iraq.

GCI-WMF received inquiries from heritage organizations from around the world interested in adopting MEGA. This led GCI-WMF to develop an open source, web-based GIS designed to inventory and manage all types of immovable heritage, including archaeological sites, buildings, structures, landscapes, and heritage ensembles or districts. The new system has the name “Arches.”

3 System Design and Development

3.1 Definition of Requirements, Design, and Development Approach

GCI-WMF undertook extensive research on best practices, standards, and principles relevant to the development of a system of this type. GCI-WMF took part in fact-finding meetings with several heritage authorities in the United States and Europe. These include the National Park Service’s CRGIS Facility and Golden Gate National Recreation Area (United States), English Heritage’s National Monuments Record and Essex County Council (UK), Inventaire General, the Rhône-Alpes Region, and the City of Lyon (France), and the Flanders Heritage Agency (Onroerend Erfgoed) and Monuments Watch Flanders (Monumentenwacht Vlaanderen) (Belgium).

Based on these efforts and experience developing MEGA, the project team determined that Arches should be designed according to the following principles:

1. **Standards-Based:** Arches incorporates international standards established in the cultural heritage and information technology fields.
2. **Broadly Accessible:** Web-based for the widest possible access, Arches will be user friendly, require minimal training for most users, and be freely available for download from the Internet to customize and install.
3. **Economical:** As an open source system, Arches will be available at no cost and allow adopters to share resources for customization and maintenance.
4. **Customizable:** The software code will be open, and the system is structured in modules to be easily extended. It will be capable of presenting its user interface in any language or in multiple languages and configurable to any geographic location or region.

The development effort, which began in June 2011, has used an incremental and iterative software design approach. Extensive unit testing of the software code is being conducted to minimize the possibility that logic defects exist within the computer code and to ensure that each component’s functions are anticipated.

Assistance from other heritage institutions has played a critical role during system development and testing. In June 2012, GCI-WMF held a peer review meeting, including representatives from English Heritage, the Flanders Heritage Agency, the U.S. National Park Service, the California Office of Historic Preservation, and the City of Los Angeles Office of Historic Resources. The Flanders Heritage Agency has provided expert advice on both system design and testing. English Heritage has

provided expert advice on incorporation of the CIDOC CRM standard and other aspects of system design. Customization of the system for the City of Los Angeles has provided the opportunity to test the system with real data and to receive feedback.

3.2 Standards Employed

A key principle in Arches' design is development based on recognized standards:

Heritage Inventory Standards. GCI-WMF have relied on two internationally adopted standards in the selection and naming of data fields for the core version of Arches:

- Council of Europe and CIDOC, *Core Data Standard for Archaeological Sites and Monuments* [2], and
- Council of Europe, *Core Data Index to Historic Buildings and Monuments of the Architectural Heritage* [3].

These standards identify minimum essential data for documenting heritage places.

They have been augmented with the aim of enhancing the system's capabilities.

Heritage Data Standards. Arches implements the semantic definitions and properties for cultural heritage data of the CIDOC Conceptual Reference Model (CRM) [4]. The CIDOC CRM has been developed since 1996 by the International Committee for Documentation (CIDOC) of the International Council of Museums (ICOM). In 2006 the International Organization for Standardization adopted it as standard ISO 21127:2006 (Information and Documentation: A Reference Ontology for the Interchange of Cultural Heritage Information) [5]. Use of this model allows Arches to consistently represent disparate, localized information and descriptions of cultural heritage in a coherent, configurable, and globally compatible way. Moreover, the CRM's incorporation will ease integration between Arches and other systems compatible with the CRM, between separate implementations of Arches, and between related information management systems. The adoption of Arches for use by an institution will require the mapping of local concepts to CRM classes and properties.

Information Technology Standards. Arches employs established open source software and open data encodings standards. The system is also designed to access and process geospatial data based on the standards and specifications published by the OGC (Open Geospatial Consortium). These include specifications for data encoding, system integration interfaces, such as WMS (Web Map Service), WFS (Web Features Service), WCS (Web Coverage Service), data visualization encodings such as KML (Keyhole Markup Language), as well as emerging standards (e.g., Tilecaching standards, geoJSON, and REST interfaces). Compliance with the OGC standards will ensure that Arches is compatible with other desktop GIS applications (e.g., ESRI ArcGIS, Google Earth, Quantum GIS), common web browsers, and online satellite imagery and maps (e.g., OpenStreetMap, Google, Microsoft). Interoperability of Arches with related information management will be essential. It will implement

Application Programming Interfaces (API) providing modern and standards-based methods for integrating multiple information management systems.

3.3 Technology Components

Arches has been developed using Python, a widely adopted and powerful open source programming language. It includes the following open source technology components:

- PostGIS, a relational database capable of managing geospatial data and implementing GIS processing tasks
- GeoServer, a GIS mapping platform that supports visualization and system integration and interoperability between Arches and other GIS systems
- ExtJS, a pure JavaScript library that supports the ability to create rich and dynamic, as well as cross-browser compatible, web applications
- OpenLayers, a pure JavaScript library that supports use of Google, Microsoft, ESRI, OpenStreetMap, and custom GIS mapping layers.

3.4 Functionality

Based on the requirements elicited from the international heritage community, the core version of Arches will incorporate digital tools in order to:

- Implement a secure means of accessing, updating, and exporting heritage asset information
- Allow system administrators to manage user access accounts and privileges
- Allow customization of language(s) and geographic or regional focus
- Query heritage asset information and display results on an interactive digital map and as a tabular grid for detailed reporting or data export
- Define and ensure a consistent, systematic, and formal workflow for managing geospatial and attribute information of heritage assets
- Allow designated users to enter geospatial and attribute information for newly recognized heritage assets and to update information associated with heritage assets already in the database
- Support temporal information, such as the date of occurrence of an event or investigative activity associated with a heritage asset
- Associate images and other documents with a heritage asset
- Track changes to the data, providing an audit report showing time and date of the change and identification of the user making the change
- Enforce and promote the standardization of data through (1) configurable data validation rules and (2) incorporation of controlled vocabularies

Arches' primary purpose is to support the creation of an inventory of cultural heritage assets and to manage the status and condition of heritage assets. Consequently, Arches purposely avoids implementing complex analytic tools in favor of an elegant, easy-to-learn user interface.

Nonetheless, Arches supports sophisticated geospatial and attribute data relationships and allows users with appropriate privileges to export data to specialized software packages for more complex analyses. In particular, Arches will:

- Allow a single heritage asset to be modeled as a single geometry or as multiple geometries
- Allow a single geometry (or collection of geometries) to represent one or more distinct heritage assets
- Support transformation of heritage assets into multiple spatial reference systems to enable the comparison of heritage information with planning, zoning, cadastral, environmental, and other geospatial data
- Contain layer library functionality, readily allowing for the incorporation of georeferenced imagery, such as aerial and satellite imagery and raster maps
- Allow users to conduct heritage asset data validation, spatial analysis, visualization, and cartography

3.5 System Content and Uses

Arches has been designed to serve a number of purposes fundamental to the understanding, appreciation, and management of heritage places. These include:

Inventory. The foundation of the data in Arches is an inventory of immovable heritage assets based on internationally adopted heritage inventory standards.

Monitoring and Management. Arches is designed as a tool to monitor threats to sites and to record change to heritage places over time. A user could search monitoring records, for instance, for recent looting at a national or regional level to assess patterns of activity and, in turn, to strategically deploy site security personnel.

The system will be useful for assessing the potential impact of planned development on heritage assets through data sharing with other government agencies involved in development planning or through the system's user-defined polygon search function. The Jordanian DoA has used MEGA-Jordan in these ways.

Arches can also be used in heritage planning. For example, within urban contexts, the system can indicate the extent and characteristics of archaeological sites within a given city. For detailed planning, data may be exported to another desktop GIS application for use in analysis and in developing proposed interventions.

Research and Planning for Investigation. Arches has been designed as a research tool with potential for use in designing research strategies. Like MEGA, Arches will allow for recording of geographic areas covered by past heritage surveys, thereby helping to identify areas in need of new investigation. Arches' advanced search capabilities will also provide for more focused research, whether for scholarly purposes or to aid in site interpretation and presentation or tourism planning. The advanced search function will allow searching the system using essentially any combination of fields, as well as at varying geographic scales—an entire country, a smaller locality, or within a user-defined polygon.

4 Next Steps

4.1 Release of Core System

GCI-WMF plan to release an “alpha” version of the Arches system as an open source project in December 2012 and a more advanced “beta” version in spring 2013. Institutions will be able to download the software at no cost, including its open code that may be freely modified, as well as related documentation. Institutions adopting Arches will likely need to customize the software to meet their particular needs and to address their specific contexts. System customization will require some expertise in the open source tools incorporated in the system and an in-depth understanding of GIS and data management. Once the system is customized, adopters will need to identify a server to host the application, and should expect to engage the services of a qualified database administrator or manager to periodically maintain it.

4.2 Formation of Open Source Community

Following the public release of Arches, further development of the software will take place through an open source community. The community will assume responsibility for maintenance of the software and decision making for the future of the Arches project. The GCI and WMF will be two of what are expected to be many stakeholders within the community. GCI-WMF are creating a dedicated website to serve as a community portal. It is envisioned that the community will adopt the technical and social infrastructure now common to online open source communities, including tools and best practices for version control, bug tracking, decision making, and communications [6]. The system’s open source license will require that code enhancements be submitted to the community for possible inclusion within the Arches code base. GCI-WMF believe a thriving open source community will be a key determinant to Arches being broadly adopted over the long term, and are therefore committed to providing resources to support the community’s website and management during its first years of existence.

4.3 Customization of Arches for City of Los Angeles

In parallel to the development of Arches for the international heritage community, the GCI is customizing the system for the City of Los Angeles, USA. For a number of years the GCI has been providing technical advice to a citywide survey of historic resources in Los Angeles that is currently underway, called SurveyLA [7]. This customization of Arches will be used to manage the records on the hundreds of thousands of properties assessed through SurveyLA and to publish them online so they are publicly accessible.

5 Conclusions

Arches is designed to address challenges faced by heritage institutions struggling to establish and sustain heritage information systems by relieving them of the need to

invest in creating individual systems. Because Arches is based on a range of internationally adopted standards, adopters of the system will be able to accrue several substantial benefits:

- *Create and manage data using best practices*
- *Exchange and compare data more easily*
- *Longevity of data in spite of advances in technology*
- *Updatable and adaptable system*
- *Promotion of standards*

In sum, GCI-WMF believe this standards-based development approach will serve as a solid foundation that heritage institutions may customize to meet their needs. Making Arches an open source application means that its adoption can be cost-effective, and allows for an IT standards-based and vendor-neutral ability to create and work with heritage data. GCI-WMF believe a flourishing open source community will be a key requirement for Arches to be broadly used over the long term, and will therefore provide resources to support the community during its first years of existence.

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