The Arches heritage inventory and management system: a platform for the heritage field

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Abstract

Purpose – The purpose of this paper is to describe the Arches heritage inventory and management system for the benefit of practitioners working with heritage inventories. Arches is a modern software platform purpose-built for the creation and management of inventories to support effective heritage place management. The system was developed as open source software jointly by the Getty Conservation Institute (GCI) and World Monuments Fund (WMF).

Design/methodology/approach – The paper discusses the needs and challenges addressed by the GCI and WMF in developing Arches, explains the system's design and functionality, reports on software releases and ongoing enhancements, describes current software implementations, and concludes by discussing the role and growth of the open source community and the Arches project's aspirations.

Findings – The needs and challenges in the heritage field that the GCI and WMF originally identified have been confirmed through interactions between the Arches project and a range of practitioners. The suitability of Arches to address these needs is demonstrated through steady growth of the open source community and an increasing number of implementations of the Arches platform.

Practical implications – Arches provides a purpose-built system that is freely available and ready for use. It offers a system that requires a marginal investment by organizations compared to building digital inventories from scratch. The Arches project has created an international community of information technology and heritage practitioners to share experience, knowledge, and skills to address their common challenges in dealing with digital inventories.

Originality/value – The paper offers heritage practitioners details on a new tool for overcoming their challenges in building and managing digital heritage inventories.

Keywords Cultural heritage, Open source software, Documentation, Inventories, Databases, Heritage management, CIDOC CRM, Geographic information systems (GIS)

Paper type Technical paper

1. Introduction

For organizations responsible for the safeguarding of cultural heritage places, inventories are an essential tool, serving as the day-to-day, "go-to" information resource for making informed decisions and applying heritage-related laws and policies. Digital inventories that harness the capabilities of modern information technologies have the potential to provide for proactive and timely responses to a full range of threats, whether from natural or human causes, in order to sustain the continued existence of heritage places for future generations.

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The Arches heritage inventory and management system[1] is an open source software platform developed jointly by the Getty Conservation Institute (GCI) and World Monuments Fund (WMF) for use by heritage institutions around the world. Arches is a web-based system that is purpose-built for managing inventories of all types of culture heritage places, including archaeological sites, buildings and structures, cultural landscapes, urban ensembles or districts, and cultural routes.

This paper provides an overview of the current state of the Arches platform. It identifies some of the key challenges that the GCI and WMF seek to address through the development of Arches, describes the software design and functionality, discusses Arches releases and implementations as of Summer 2016 as well as software enhancements currently under development. It concludes by discussing the growth of the Arches open source community and the project's future aspirations.

2. Challenges addressed

Before offering a more detailed description of the Arches system, it may be useful to describe the range of pervasive challenges that heritage organizations throughout the world face in developing and maintaining digital heritage inventories:

- Complexity of heritage data: cultural heritage data are complex. Heritage organizations often need to track the evolution and changing conditions of a heritage resource, including changes in form, function, and sometimes in location. Moreover, each of these changes needs to be preserved as part of the information record. Cultural heritage data frequently incorporates subjective interpretations that may need to be qualified, adjusted, and improved over time. The location of heritage resources may need to be described in multiple ways, including through street addresses, cadastral property boundaries, and at times through complex spatial geometries. Also, heritage organizations often must track relationships between heritage resources and other types of information, such as persons, organizations, events, and documents. These are some of the many complexities of heritage data that pose formidable challenges to heritage organizations as they develop and use digital inventories.
- Rapid technological advancement: the development of information technologies continues to advance extremely rapidly, as it has for more than half a century. Keeping up with information technology (IT) sector developments often poses a substantial challenge when heritage organizations must decide whether or not to invest in software applications.
- Managing, updating, and sustaining inventory records over the long term: Heritage organizations periodically carry out or commission cultural resource surveys, which generate substantial amounts of data. Organizations are challenged with transitioning from managing survey data, representing conditions at a particular point in time, to incorporating survey data into an inventory system which allows for updating information over time. Before embarking on a major survey, a heritage organization should ideally have a digital inventory system in place to manage the survey data collected. In the absence of well-designed information management systems, data, and thereby knowledge about cultural resources, can be lost permanently. Data can become inaccessible because it is created in proprietary formats that are no longer supported. Lost data can represent years of effort invested by multiple generations of contributors.

- Cost: software is expensive to develop, customize, and maintain, and cultural heritage organizations are typically chronically underfunded. Such organizations typically do the best that they can on a limited budget, and in doing so often develop systems that do not offer all of the functionality that is essential in addressing their requirements.
- Duplicative expenditures: heritage organizations around the world spend scarce resources in isolation to create individual digital inventories. Their investments often address needs that are very similar to those of many other institutions. Individual projects commonly spend substantial sums on creating databases from scratch, reducing the amount of resources available for recording and protecting heritage places.

In sum, heritage organizations often have significant resource constraints while also making duplicative investments in creating separate inventory systems that address very similar needs.

In the Summer of 2011, the GCI and WMF decided to jointly invest in the development of a generic software platform to help address these challenges. Using the latest technologies and an open source[2] approach, the Arches heritage inventory and management system was developed and is now freely available to international heritage organizations to independently deploy and customize to meet their specific needs.

3. Overview of system design and functionality

Arches has been designed to address the challenges described in the previous section while taking the needs of its target audience into account. To this end, the design of Arches has followed a set of key guidelines:

- *Economical*. Arches is designed to be economical to adopt. As open source software, Arches is available at no cost. It allows those who utilize it to pool resources for software maintenance and enhancements.
- *Customizable*. Arches is freely customizable. The software code is open, and the system is structured in modules that can be easily extended. It is capable of presenting its user interface in any language or in multiple languages and scripts and is configurable to any geographic location or region.
- *Standards based[3]*. Arches incorporates internationally adopted standards for heritage inventory, semantic data modeling, controlled vocabularies and IT, leading to better practices in the creation and management of heritage data. The incorporation of standards facilitates data exchange and structures data to retain its viability as technology advances.
- *User friendly*. Arches is designed to be as intuitive as possible so that most users require minimal technical training.
- *Broad, controlled accessibility*. Arches is web-based to provide for wide access once installed. However, access can be controlled to a granular level based on individual or group privileges.

Arches has been designed to support a number of activities which are essential to the heritage management process:

- identification and inventory;
- research and analysis;

- heritage impact assessment, monitoring, and risk assessment;
- emergency preparedness and response;
- planning for investigation, conservation, and management activities; and
- providing information to the public, governmental authorities, and decision makers to promote their awareness and appreciation of heritage.

Arches is an enterprise-level software to be used at an organization or project level. Implementers will need to identify a server to host the Arches system and, as with any enterprise-level software, they should expect to have access to a qualified database administrator or manager to maintain it.

The Arches platform is geospatially and semantically enabled and is specifically designed to manage the complexity of cultural heritage data explained previously. The following describes key features of the system's functionality. More detailed information may be obtained from the Arches project website.

The default version of software is structured to manage information on six Arches resource types: heritage resources (e.g. archaeological sites, buildings, structures, landscapes), heritage resource groups (e.g. urban districts, ensembles, thematic groupings), actors (e.g. persons, organizations, and cultural groups), historical events (e.g. floods, epidemics, battles), activities (e.g. investigations; conservation interventions, and information resources (e.g. documents, images, videos, 3D models), as shown in Figure 1.

Arches allows for the creation of networks of relationships among all six Arches resource types, as shown in Figure 2. This allows, for example, the tracking of multiple roles of persons or organizations – e.g., an architect who was also an owner of a heritage resource – and allows such roles to be clearly denoted within a timeframe.

Moreover, Arches can record location information in multiple formats (e.g. text description, address, cadastral parcel) and as different geometry types simultaneously. In other words, an Arches resource record can use any combination of point, line, and polygon data, in addition to other attribute data, to describe location. This is not easily possible using traditional GIS (Figure 3).

Data within Arches is structured for widespread interoperability and integration. Data exported from Arches are self-describing – i.e. it is not dependent upon any specific software program to be machine-readable and understood. This helps protect the meaning and longevity of data for the future.

Arches incorporates a reference data manager (RDM) module that is specifically designed to manage cultural heritage terminology within the system. It includes the ability to build new thesauri or import and edit existing thesauri such as the Getty's Art and Architecture Thesaurus (AAT)[4]. Simply stated, the RDM facilitates the creation of customized word lists that are relevant for each individual implementation. Terms in the RDM can then easily be included in dropdown menus that power data-entry forms. Using the RDM enforces data validation and adherence to standards, which enhances the searching process and facilitates the entry and retrieval of valid multi-lingual content. To support data retrieval, Arches utilizes ElasticSearch, a high-performance search engine that is quick and capable of handling large datasets (Figure 4).

Security controls for data access within Arches are easily customizable to meet sometimes sensitive and highly individualized requirements. The system allows organizations to control data access to the level of individual data-fields, which is based

Figure 1.
Arches default resource types

on individual or group privileges. This means that an implementer of Arches can specify which particular users may edit which specific data fields, or what visitors (if public access is allowed) may see what types of data. The system also preserves all changes to records over time, using a robust audit history that tracks all edits to records, including their time stamp and author.

Arches employs many standards, including the CIDOC conceptual reference model (CRM), an ISO standard for the exchange of cultural heritage information, to model cultural heritage entities and the relationships between them (Carlisle *et al.*, 2014; ISO, 2014; Le Boeuf *et al.*, 2015). Arches can accommodate a range of basemaps, such as those provided by OpenStreetMap, Google, and Microsoft, as well as online satellite imagery and other imagery (such as historical maps) that are offered by other services. It accesses and processes geospatial data based on the standards and specifications of the Open Geospatial Consortium (OGC). Compliance with the OGC standards ensures that the system is compatible with desktop GIS applications (such as ESRI's ArcGIS, Google Earth, or Quantum GIS), modern web browsers, and online mapping services.

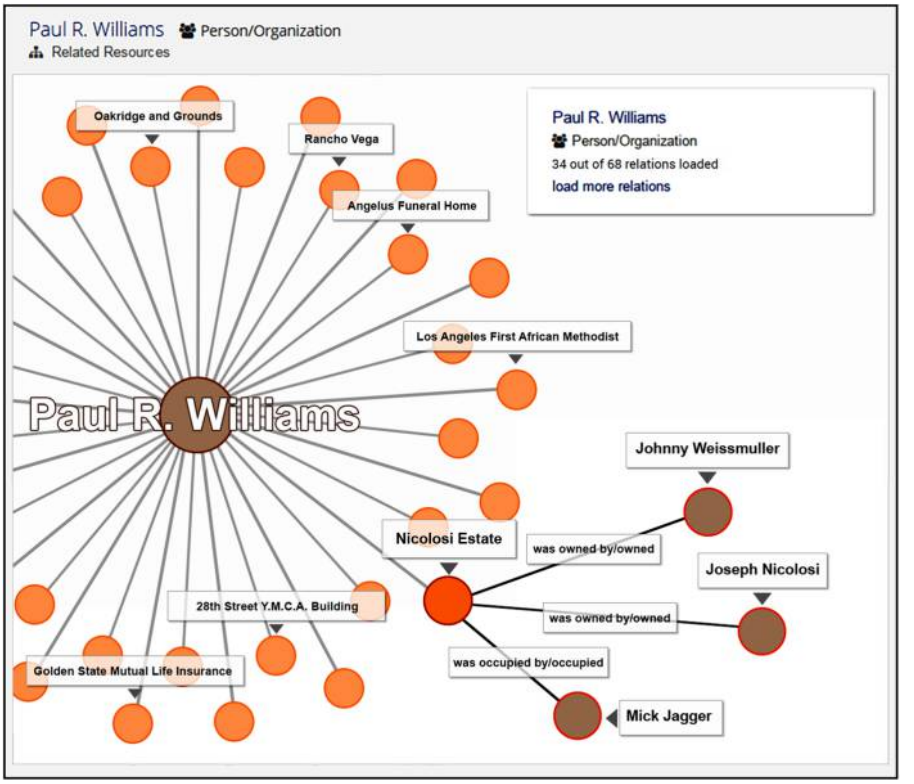


Figure 2.
The related resources graph reveals relationships between Arches resources

Note: In this instance between an architect and heritage resources as well as other persons related to those heritage resources (such as owners and occupants)

4. Software releases and new development

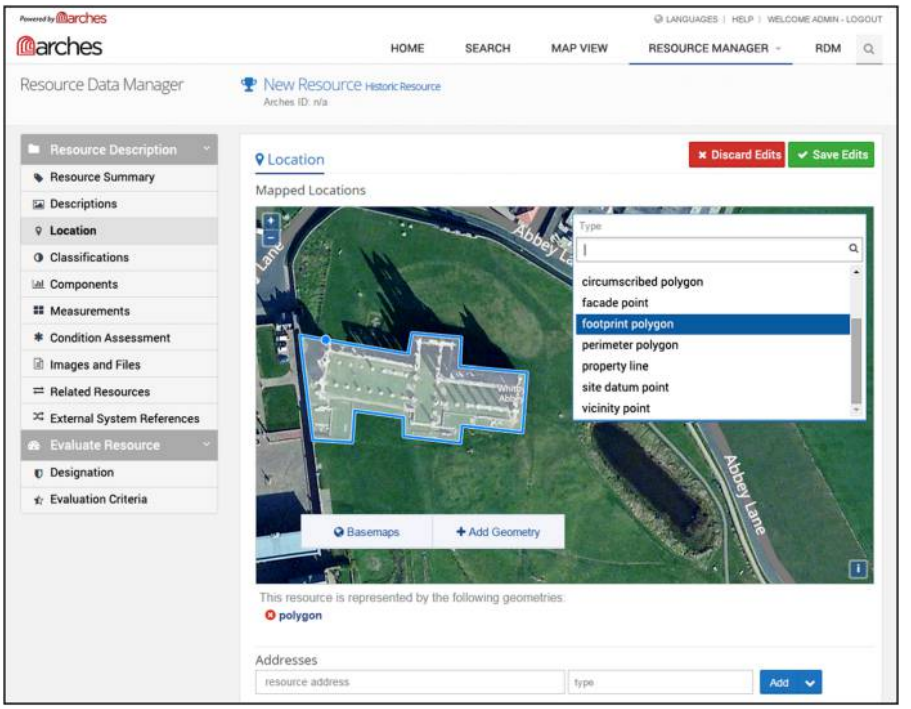
Version 1.0 of the Arches open source code was released in October 2013 and version 2.0 in March 2014. The latest version of the software, version 3.1, was released in November 2015.

As of Summer 2016, the Arches project is preparing a number of substantial software enhancements that will be included in the release of Arches version 4.0, planned for the end of 2016. These include an Arches mobile data-collection app; a mobile data-collection project manager to allow a system administrator to define the scope, area, timeframe, and users for field data-collection activities; an installation wizard and an application manager to ease software deployment and configuration; a user profile manager; enhancements to allow the incorporation of locally stored satellite imagery and other basemaps; and a data import/export manager.

5. The system in use

As of Summer 2016, the following are some known Arches implementations:

- HistoricPlacesLA: the City of Los Angeles, has deployed Arches as HistoricPlacesLA, the official Los Angeles Historic Resources Inventory, to serve both as a tool to fulfill its obligations under federal, state, and local historic preservation laws and to make information publicly accessible[5].



Note: Other types of locational data include addresses, administrative areas, cadastral references, and descriptions
Source: Microsoft Bing API data reprinted with permission

Figure 3.
Using the location data-entry form to draw a polygon on the map and create a new spatial geometry for a heritage resource

- ASOR Cultural Heritage Initiatives for Syria and Iraq: the American Schools of Oriental Research (ASOR) is using Arches as part of its collaboration with the US Department of State to further their aims of documenting damage, promoting global awareness, sharing information with other organizations around the world, and planning emergency and post-war responses to the war-torn cultural heritage of Syria and areas of Islamic State activity within Iraq[6].
- Philippine Heritage Map: a Manila-based non-profit has implemented Arches as the Philippine Heritage Map in order to publish online information collected through an ongoing national-scale heritage survey[7].
- Endangered Archaeology in the Middle East and North Africa: the endangered archaeology in the Middle East and North Africa project based at the Oxford University is using Arches to record archaeological sites and landscapes that are under threat across the Middle East and North Africa, including from rapid population growth, urban expansion, agricultural development, warfare, and looting.
- Cane River Heritage Inventory and Map: the Cane River National Heritage Area in Louisiana, has implemented Arches as the Cane River Heritage Inventory and Map to both manage information on heritage resources and to promote public knowledge, appreciation, and interest in those resources[8].

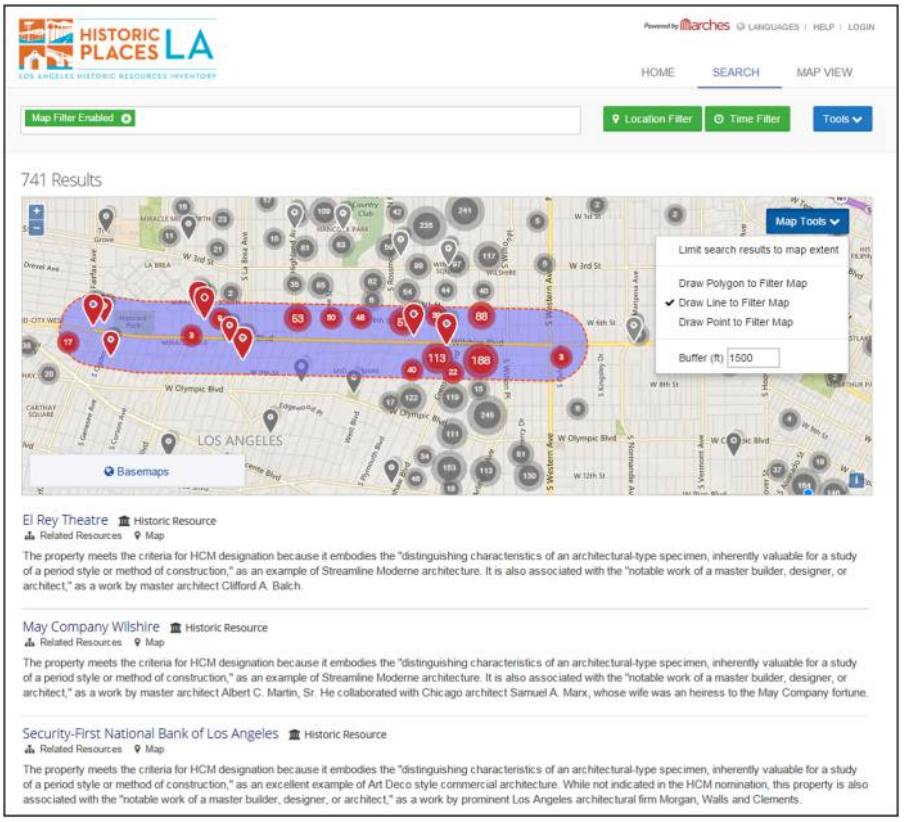


Figure 4.
Using the location filter in Arches, resources that would be impacted by a proposed development project can be quickly identified

Source: Microsoft Bing API data reprinted with permission

- Armed Forces Retirement Home: the Armed Forces Retirement Home, a 272-acre historic residential campus in Washington, DC, established in 1851 for military veterans, is using Arches as a tool inventory and help manage its cultural resources, which comprise a US National Register Historic District.
- Queen Anne's County, Maryland: Queen Anne's County is implementing Arches to present and help preserve more than 300 years of its history of individuals, properties, and events that are significant to the nation, Maryland, and Queen Anne's County. This Arches deployment is slated to go public in Spring 2017.
- Early Watercraft: Early Watercraft is a research project at the Faculty of Computer and Information Science, University of Ljubljana, that has deployed Arches to present information on early Slovenian logboats and potentially provide a framework to manage and publish data on early watercraft throughout the world[9].

A number of other implementations of Arches are currently under preparation worldwide for heritage-related purposes. These include deployments as national-scale inventories in Asia and the Caribbean, as city-level inventories in England, and to

record ancient sites throughout Egypt. Other implementations may exist, but given that the code is open source and freely available to download and install, the authors may not necessarily be aware of them (Figures 5-7).

6. The Arches community and project aspirations

Choosing an open source approach provides a range of benefits. The Arches open source license obligates those who enhance the software to share those improvements with the entire community. The following is an example of how this provides benefit in practice. Through its use of the Arches platform, a state transportation agency in the USA enhanced the Arches software to enable security to be controlled on a field-by-field level. This improvement now resides in the core Arches software code that is publicly available. (It may be of interest to note that in this case the enhancement was provided by a non-heritage entity.) Also, given that the software code is openly modifiable, organizations wishing to use Arches do not need to wait for a proprietary software company to release new features that they may need. Customizations and enhancements are immediately possible for those who have or can mobilize the resources to implement them. In addition, multiple organizations that share common requirements may opt to pool their resources for software maintenance and enhancements.

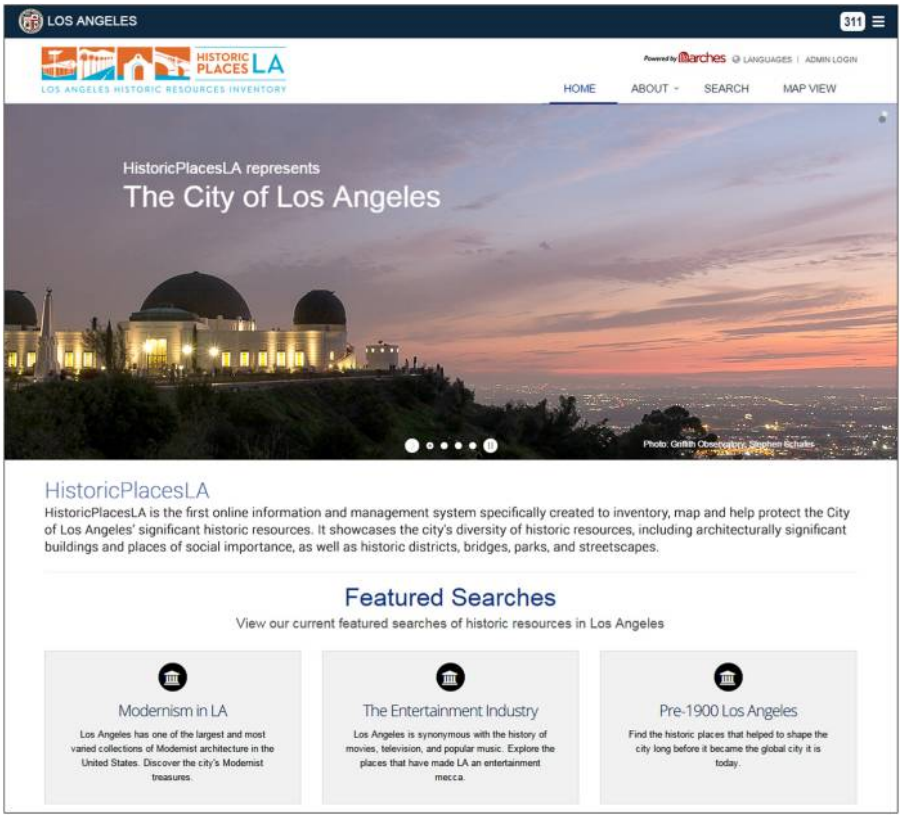


Figure 5.
Screenshot of HistoricPlacesLA, the Los Angeles Historic Resources Inventory

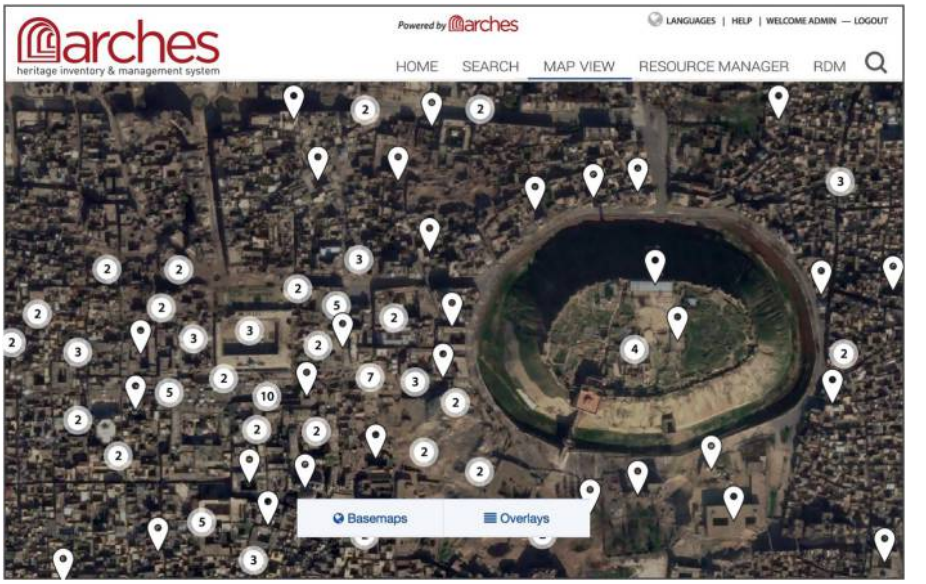


Figure 6.
The American Schools of Oriental Research (ASOR), through its collaborative project with the US State Department, is using Arches to document damage to heritage and plan emergency and post-war responses in Syria and northern Iraq

Note: Seen here is the citadel and surrounding area in the ancient city of Aleppo
Source: Microsoft Bing API data reprinted with permission

Figure 7.
Screenshot of the Philippine Heritage Map

Source: Microsoft Bing API data reprinted with permission

The Arches community serves a broader function in this area of practice. In the authors' experience, practitioners working with heritage inventories and information systems have had limited opportunities to engage with each other on an international level. CIPA has provided a venue for this type of engagement within sessions on digital

heritage inventories at its 2013 and 2015 symposia. However, CIPA symposia are only held every two years. The authors believe that the Arches community forum serves as an online mechanism through which practitioners, whether heritage professionals or IT specialists, can engage with one another on a range of relevant topics. As of summer 2016, the Arches forum has more than 300 members from across the globe.

Inventories are the most important tool to manage the range of threats confronting our vulnerable heritage places. Inventories are most effective and are able to reach their fullest potential when employed through modern information technologies that offer widespread and quick access to targeted information that is easily updated to reflect changing conditions.

In an environment of diminishing resources for heritage organizations internationally, the GCI and WMF have chosen to invest in creating a modern, purpose-built, and standards-based software platform for the heritage field. The Arches platform provides a solid framework that heritage institutions can take and, in turn, make marginal investments to customize in order to meet their specific requirements.

Through Arches, the GCI and WMF aim to break the cycle of heritage organizations expending scarce resources on making duplicative expenditures to independently create digital inventory systems. This saves precious resources that can be deployed toward achieving the ultimate higher aim of sustaining our cultural heritage.

Notes

1. For more information on Arches, visit the project website (http://archesproject.org/), where along with participating in the community forum visitors can interact with an online demonstration version, download the software code, access documentation, view the project roadmap, and receive project updates.
2. Open source refers to a computer program made available free of charge to the general public and its source programming code open and accessible, which means that its original design may be modified. Customizations, upgrades, or improvements made to the software by anyone must remain freely available. Open source software has an entirely different meaning than open data. Open data refers to the notion that certain data should be freely available to anyone to use and republish as they desire without restrictions by copyright, patents, or other means of control (Auer *et al.*, 2007). Implementers of open source software systems may choose to have data be openly available, closed (i.e. available to only a certain group of authorized system users), or a combination of the two.
3. For additional information on the range of standards incorporated in Arches, see: http://archesproject.org/standards/ (accessed January 15, 2016).
4. The Getty Art and Architecture Thesaurus, one of the Getty Vocabularies, is published as linked open data and available at: www.getty.edu/research/tools/vocabularies/aat/ (accessed January 27, 2016).
5. HistoricPlacesLA, the Los Angeles Historic Resources Inventory, is available at: http://historicplacesla.org/ (accessed January 20, 2016).
6. The ASOR and US State Department collaborative implementation of Arches for the cultural heritage initiatives for Syria and Iraq has not been made publicly accessible. However, information on the initiatives is available at: www.asor-syrianheritage.org/ (accessed January 20, 2016).
7. The Philippine Heritage Map is available at: www.philippineheritagemap.org/ (accessed January 20, 2016).

8. The Cane River Heritage Inventory and map is available at: http://crhim.canerivernha.org/ (accessed January 20, 2016).
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