

# CARARE: Connecting Archaeology and Architecture in Europeana

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**Abstract.** CARARE is a best practice network funded by the European Commission's ICT Policy Support Programme. The network brings together heritage agencies, organisations, archaeological museums, research institutions and specialist digital archives to establish a service that will make digital content for Europe's unique archaeological monuments and historic sites interoperable with Europeana. As well as bringing 2D images and text documents to Europeana, CARARE will bring a mass of geo-referenced content to Europeana and adds 3D and Virtual Reality as new content types. This paper looks at the activities of the CARARE project in establishing and aggregation service for the archaeology/architecture domain including work to mediate the rich metadata held by the domain for presentation in the Europeana Data Model, the use of semantic web technologies such as SKOS, and work on the documentation and preparation of 3D and VR content for online publication and discovery via the Europeana search service.

**Keywords:** CARARE, Europeana, Archaeology, Architecture, Heritage Data.

## 1 Introduction

CARARE is a Best Practice Network, funded under the European Commission's ICT Policy Support Programme, which started on 1 February 2010 and will run for three years. It is designed to involve and support Europe's network of heritage agencies and organisations, archaeological museums and research institutions and specialist digital archives in making the digital content for the archaeology and architectural heritage that they hold available through Europeana, and will establish an aggregation service for the archaeology/architecture heritage domain. CARARE is one of a suite of projects which have been funded by the European Commission to help develop Europeana, and builds on the work of earlier projects which have helped to establish a framework for interoperability within the domain.

### 1.1 Background and Related Work

From the 1980s there has been work at international level to establish core standards for inventories of historic buildings, archaeological sites and cultural landscapes with

the aim of improving their management through inclusion in planning and sustainable development processes. The Core Data Index to Historic Buildings and Monuments of the Architectural Heritage established by the Council of Europe was rapidly followed by the CIDOC Core Data Standard for Archaeological Sites and Monuments [1][2]. These standards have been implemented in information systems by heritage agencies across Europe to fulfil the obligations of the Granada and Valletta conventions [3][4] and thus providing a starting point for interoperability and information access. The establishment of the European Heritage network (HEREIN) by the Council of Europe has played an important role in promoting the exchange of information on heritage policies across Europe also contributing to the development of multilingual terminology resources [5].

Two projects have been important in terms of their work on interoperable portals for the cultural heritage and multilingual terminology. AQUARELLE (1996-1999) was funded by the European Commission's telematics programme to demonstrate resource discovery across distributed data sources from the museums and heritage domain; it also developed a multilingual thesaurus server to enable user browsing. [6] [7]. ARENA (2000-2004) was funded by the Culture 2000 programme project to digitise archaeological archives from six countries and make them accessible to users via the ARENA portal. The ARENA project has been described as a "path finding" project which set out to investigate and demonstrate the reality of using ICT to enable archaeologists to communicate and share data throughout Europe [8][9][10].

More recently DARIAH (Digital Research Infrastructure for the Arts and Humanities) has been funded by the European Commission's FP7 programme to investigate, develop and maintain infrastructure to support ICT-based research practices across the humanities and arts. In its preparatory phase the project is building on work by the earlier ATHENA project to provide a demonstrator of service oriented architecture enabling access to electronic archives [11].

The EPOCH Network of Excellence, funded through the EC's Sixth Framework programme focussed on the development of open source tools and service to support 3D visualisations and the flows of information from archaeological discovery to education and dissemination [12]. Of particular relevance to CARARE are the open source tools such as ARC 3D, MeshLab, CityEngine and InMan which have become available to cultural institutions to use in the 3D visualisation and interpretation of historic buildings, archaeological monuments and landscapes as a result of the project. SCULPTEUR, an earlier project supported by the EC's 5th framework programme is also of interest for its work demonstrating the potential to navigate, search and retrieving 2D images and 3D models using a combination of metadata and content-based searching.

## 1.2 Cultural Heritage without Borders

These projects and others (such as the Pathways to Cultural Landscapes Project [13]) illustrate the desire amongst researchers and heritage professionals for cooperation across national borders and to embrace the possibilities offered by information technology to improve search and discovery of digital content.

Europe has a common cultural heritage in which present national borders have little relevance for "cultures" through prehistory and early historic periods. There has

been a long-term ambition amongst archaeologists of sharing heritage information across borders through interoperable information systems able to query data from several nations at once and present the result in a meaningful way to users. The potential for cross-border research was discussed by Dam and Hansen in their review of the Arena project [14].

This ambition is very much in line with the initiative to establish Europeana as a single point of access to Europe's cultural heritage and makes entry to Europeana a logical next step for heritage information.

## 2 Introduction to CARARE

CARARE has been established as a Best Practice Network with funding through the European Commission's ICT Policy Support Programme to involve Europe's network of heritage agencies and organisations, archaeological museums and research institutions and specialist digital archives in the Europeana initiative.



**Fig. 1.** CARARE project logo [15] © CARARE 2010

The project started on 1 February 2010 and will run for three years. It is designed to:

- Support its member organisations in making the digital content for the archaeology and architectural heritage that they hold available through Europeana,
- aggregate content and deliver services,
- and enable access to 2D, 3D and Virtual Reality content for heritage objects for the users of Europeana.

## 2.1 Archaeology and Architecture in Europeana

The major objective of CARARE is to increase the quantity and quality of digital content for the archaeological and architectural heritage that is available to users of Europeana. Such content is particularly relevant to Europeana having great potential to support services for cultural tourism and users with interests in local history, family history and humanities research.

Analysis of the content of Europeana in summer 2009, following the initial ingest of 5 million items to support the launch of the prototype service, concluded that there was a need and demand to increase the available content for the archaeological and architectural heritage.

CARARE proposes to meet this demand by enabling an estimated 2 million items for 1 million unique monuments, buildings, landscapes and heritage sites to be included in Europeana. Including content from heritage organisations in Europeana alongside material from museums, libraries, archives and audio-visual collections will enable sources to be brought together and researched in ways that have rarely been possible previously. It will become possible to bring together distributed collections which have been scattered as a result of long ago boundary changes or the activities of different researchers and institutions.

## 2.2 Adding a New Dimension to Europeana: 3D and VR

In addition to bringing 2D images and text material to Europeana, CARARE will have a special focus on the 3D and virtual reality models created by archaeologists and architectural historians to record, analyse and present heritage sites and objects. The project aims to solve issues concerning the harvesting and presentation of these formats for Europeana and for other domains.

One issue that is particular to 3D is that users are often required to install browser plug-ins in order to view 3D content. As 3D formats and viewers are relatively unstandardized there is a risk that Europeana users could be directed to install many different plug-ins, this is particularly the case as it is intended that the 3D content will remain on the original content provider's web-servers. To simplify matters for Europeana users, CARARE will make recommendations to content providers on best practices including a set of visualisation technologies for Europeana which are multi-platform, multi-browser and (if possible) do not require the installation of plug-ins.

## 2.3 Place and Geographic Information

CARARE will also make a positive contribution to Europeana by bringing a critical mass of content which includes spatial coordinates as well as place names, and also the expertise of the heritage community in working with geographic information and geographic information retrieval.

The work by CIDOC and the Council of Europe in establishing Core Index data for monuments and historic buildings included specifications for place information. This work provided the starting point for the widespread implementation of GIS by heritage agencies as technologies became available. Place is one of the most frequent starting points for enquiries about the archaeology and architectural heritage of an area. Importantly the inclusion of spatial coordinates in

record sets enables archaeology and architecture data sets to be included in geo-portals alongside other datasets used in planning, development control, tourism and other map-based services.

Differing map projections, coordinate systems and standards cause issues when bringing together spatial data sets from different regions. The 2007 INSPIRE Directive seeks to solve this issue for environmental datasets by establishing an Infrastructure for Spatial Information in the European Community [16]. Many heritage agencies are currently working towards implementing the INSPIRE directive and this is an area where CARARE can contribute expertise to Europeana.

### 3 Content

CARARE is contributing to the expansion of Europeana both in terms of involving new content providers from the archaeology/architecture domain in Europe and in terms of the content being made accessible. More than 2 million digital objects have been identified in the initial survey by partners. The actual content that these partners will make available to Europeana via CARARE includes:

- archive items created by local citizens, visitors, scholars and scientists who have explored, described and depicted heritage sites since the earliest times, and
- photographs, measurements, drawings, reports, plans, maps, 3D and virtual reality models created by heritage agencies in support of their mission to manage and promote understanding of the heritage sites within their area.

#### 3.1 3D, Virtual Reality and Virtual Reconstructions

3D and virtual reality models are increasingly used in the archaeology/architecture domain to record, analyse and present complex monuments and buildings (see figure 2). The initial content to be made available through CARARE includes 3D and virtual reality models of sites that are of high heritage interest at international, European, national and local level and includes:

- 3D model of the Pompeii civic forum
- Virtual reality model of Ta' Hagraat Temple, Malta
- 3D scan of the fortifications at Gdańsk, Poland
- SVG plan of Silchester Roman town, UK
- 3D models and virtual reality reconstructions of the Paphos theatre, Cyprus and also
- 3D models of ceramic vessels

This content type is not yet represented in Europeana. The initial focus in establishing the Europeana Service was on building a critical mass of textual and image based content with moving image and audio content being added more recently through projects such as the European Film Gateway, EU Screen and Europeana Connect. The first prototype of the Europeana service ([www.europeana.eu](http://www.europeana.eu)) was designed around four major content types: images, text, audio, moving image. One of CARARE's activities will be to define the functional specifications to establish both the workflow and a new search facet for 3D and VR content.



**Fig. 2.** Middle Byzantine Church, 1200 A.D., Episkopi Manis, Hellas © The Ministry of Culture and Tourism - 5th Eforate of Byzantine and Post-Byzantine Antiquities (3D Digitization by CETI, Athena Research Centre)

## 4 Metadata

CARARE will establish an aggregation service for archaeology/architecture organisations. This service will harvest metadata from its content providers, providing data mapping tools to enable the metadata to be transformed into Europeana friendly formats. This transformed metadata will in turn be made available by the CARARE service for harvesting and ingest by Europeana. The aim is to provide the necessary guidance, standards and infrastructure to establish a channel which improves the interoperability of digital content from the archaeology/ architecture domain with Europeana.

### 4.1 Achieving Semantic Interoperability

Achieving syntactic and semantic interoperability across the metadata sets and the different media formats that exist in heritage organisations is the largest challenge for CARARE. To achieve interoperability between the different native metadata formats, CARARE is exploring the use of the CIDOC CRM to mediate between the semantics of the original data and the standards and schemas defined by Europeana.

The CIDOC CRM (Conceptual Reference Model) represents an 'ontology' for cultural heritage information and describes in a formal language both explicit and implicit concepts and relations which are relevant to the documentation of cultural heritage. The CRM provides the basis for mediating cultural heritage information and the semantic "glue" needed to transform local information sources into coherent global resources [17].

### 4.2 Mapping and Transformation

CARARE will ask its content providers to map their native metadata schema to an implementation of the CIDOC CRM which will in turn be mapped to the Europeana

Data Model (EDM) [18]. This approach provides flexibility, allowing for development both by Europeana in its data model and the metadata that it maintains to support the main function of search and discovery and also allowing for the maintenance and development by content providers of richer descriptions of heritage objects.

An early decision for CARARE has been selecting an implementation of the CIDOC CRM for use in the mapping tool which will be made available to CARARE content providers. Both RDF and XML implementations of the CRM have been made available and are published on the CIDOC website. Early discussions with CARARE content providers revealed that there were barriers to the implementation of the full RDF schema which would increase the training requirement for heritage professionals who would be undertaking the data mapping. XML implementations of the CRM were found to be more user friendly and to offer the potential for customization for the heritage domain.

### 4.3 MIDAS Heritage

MIDAS Heritage is a data standard for information about the historic environment which was developed for use in the UK and Ireland and is maintained by the Forum on Information Standards in Heritage [19]. MIDAS builds upon the following sources:

- The development of international data standards for the cultural heritage sector, including the Core Data schemes for historic buildings and archaeological monuments and the CIDOC CRM;
- A first edition of the MIDAS standard [20];
- The experience of the members of the Forum on Information Standards in Heritage in its application (FISH).

MIDAS covers three major areas:

- the individual assets that form the historic environment (buildings, archaeological sites, shipwrecks, archaeological areas of interest and artefacts);
- the work that is undertaken to understand, protect and manage change to those assets (events);
- sources of further information (archives).

In addition to the published documentation, presentations and training materials available for the MIDAS standard, the Forum on Information Standards in Heritage has developed an interoperability toolkit to assist in the process of moving information between information systems with funding from English Heritage and the National Trust [21]. The tools include:

- MIDAS XML
- INSCRIPTION controlled vocabulary and identifiers
- Tools to validate the contents of MIDAS XML files.
- Historic Environment Exchange Protocol (HEEP), a web service protocol to standardise remote querying on heritage data

After a review of the MIDAS heritage standard alongside other implementations of the CIDOC CRM and the CRM itself, CARARE concluded that the standard was of interest for use in the project. The fact that MIDAS builds on the work by CIDOC and the Council of Europe on Core Data for archaeology and architecture gives the schema a European relevance as it covers concepts that are familiar to most heritage agencies in Europe that maintain monument inventories. Mapping between MIDAS and the CIDOC CRM also facilitates its use by CARARE as a schema to mediate between the native metadata held by CARARE partners and the Europeana Data Model.

English Heritage are now working with the CARARE project to internationalise MIDAS, which includes updating the standard to conform to the INSPIRE directive on geographic information.

#### 4.4 Europeana Data Models

Europeana has developed metadata specifications to support the functionality of its search portal and interoperability with the numerous metadata schemes in use by its content providers. The Europeana Semantic Elements (ESE) was published in summer 2008 to support the first prototype portal [22]. There have been minor revisions to the ESE schema since its first publication and it will continue to be used in the new release of the Europeana portal due in summer 2010. But the Europeana v1.0 project has been working on the Europeana Data Model (EDM), based on Semantic Web principles, to enable additional functionality to be incorporated in future releases of the Europeana portal due in summer 2011.

The ESE schema was based on Dublin Core Metadata and, while it supported item level retrieval in the first Europeana prototype portal well, it did not differentiate between temporal and spatial coverage sufficiently well for the archaeological or architectural heritage. The EDM schema is a semantically richer schema which takes into account concepts from the CIDOC CRM and in making clear distinctions between the concepts of time-span, place, agents and events (see figure 3) is more suited to archaeological and architectural heritage objects. For this reason the CARARE project has elected to provide data to the 2011 Europeana release in EDM format.

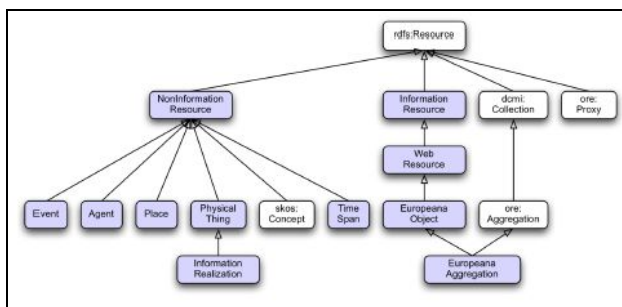


Fig. 3. The EDM class hierarchy © Europeana 2010



An important development in the current version of the EDM is its re-use of concepts from ORE, RDF and SKOS opening the potential for exploitation of semantic web technologies. CARARE plans to benefit from these capabilities and is looking at the SKOSification of multilingual terminology resources for the heritage and at the potential for establishing linked data for use within the domain.

## 5 Harvesting and Aggregation

Europeana is based on a distributed architecture with aggregation services such as CARARE harvesting and aggregating metadata from content providers and then being targeted for harvesting Europeana itself.

CARARE will establish a network of repositories amongst its content providers which are interoperable with its harvester. The OAI-PMH communication protocol [23] is the preferred method for metadata delivery to CARARE although other web-services may be considered with individual content providers. From the perspective of content providers, the use of OAI-PMH has benefits as it can be implemented on many systems using Open Source software and is increasingly being implemented by vendors of repository systems. It is one of the key standards that have been promoted to culture sector stakeholders and the resultant availability of tools means that the barriers to entry for stakeholders, especially those who are creating new repositories, are relatively low.

### 5.1 CARARE Workflow

To enable the aggregation of quality metadata into Europeana, CARARE is implementing an ingestion workflow, which centralises some processes in the CARARE repository and enables content providers to be involved in controlling the quality of the metadata produced for the Europeana environment. The stages of the workflow are as follows:

- 1) Metadata will be harvested from each content provider and to the CARARE repository where it will be indexed and stored in an XML data format. Content providers will be able to declare the harvest as either complete (new, updates or deletes) or partial (new or updated or mixed).
- 2) Content providers will complete a mapping of the data fields in their native metadata to CARARE's implementation of the CIDOC CRM, MIDAS Heritage using a web-based metadata mapping tool provided by the National Technical University of Athens for the CARARE project.
- 3) CARARE will complete a mapping of the CRM implementation to the Europeana Data Model (current version). It is important to note that the EDM schema is still evolving as new functionality and content types are identified for Europeana. By asking content providers to map their data to an intermediary schema (step 2) and then mapping this schema to the EDM, CARARE aims to avoid asking its content providers to do repeat mappings.
- 4) CARARE will convert selected multilingual thesauri identified by CARARE content providers to SKOS using automated tools.

- 5) Content providers will be able to view their metadata transformed in Europeana’s format in a test environment to check and resolve any data issues which might include:
  - i) Refining the data mapping
  - ii) Mapping their terminology to selected lists
  - iii) Normalizing the data to Europeana standards, e.g. adding the language of the metadata, content type etc.
  - iv) Linking terms to SKOS thesauri
- 6) CARARE will run a quality control check, for example to check for any missing values or malformed data and report back on the content providers data.
- 7) Once the checks are completed validated Europeana metadata will be made available in the CARARE OAI-PMH repository for harvesting by Europeana. The SKOS thesauri created and used in CARARE will also be made available to Europeana.

CARARE’s workflow is illustrated below in figure 4.

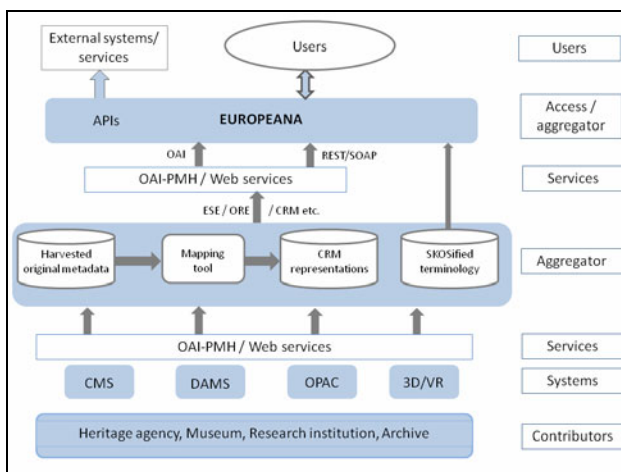


Fig. 4. CARARE’s harvesting and aggregation service © CARARE 2010

## 6 3D Content

CARARE has a specific work package which is focussing on the issues around making 3D and VR content accessible to Europeana. The content survey will help to identify in more detail the formats that are held by CARARE content providers, initial feedback indicates that there is a wide range which includes simple models of museum objects, complex reconstructions of major archaeological sites, virtual tours, CAD data files (useful for students and professional users), and 3D models associated with large related 2D archives, with different levels of granularity and considerable variation in the metadata that is currently available.

The metadata needed to support the description, preservation and discovery of the 3D/VR models produced in the archaeology/architecture domain is one area that is under discussion. On a professional level it is important to document the methods and techniques used in capturing 3D models of real-world archaeological and architectural objects, and in creating virtual reconstructions of these sites as they appeared at various times in the past. Such information may be less immediately important to a general user of 3D models, who may rely on descriptions of the site, its associations and characteristics (who, what, when) and location for resource discovery, and on technical metadata describing the format of the model in order to view the model itself. CARARE is looking at these metadata requirements in order to make recommendations to its content providers and to Europeana.

Another aspect of the metadata for 3D which is under review is the relations between the parts of complex models (which may comprise of a series of linked 3D objects) and between 3D models and linked information sources. 3D and Virtual Reality models increasingly include links to external digital content such as text documents and images, which enhance their educational value. These complex relationships between objects and metadata also increase the complexity of ingesting 3D collections into a repository. The 3D-COFORM project, with funding from the European Commission's 7th Framework programme, is carrying out a programme of research in this field, looking in particular at 3D documentation and the deployment of affordable, practical and effective technologies for use in the cultural heritage sector [24]. At the technical level, it is helpful that 3D-COFORM is investigating the relationships between the CIDOC-CRM and METS as ontologies, provenance data encoding and standard geometric representations (X3D, Collada). CARARE is following the research activities of the 3D-COFORM project consortium with interest and will take its results into account when making practical recommendations to the archaeology/architecture community.

One more aspect of 3D which is under consideration in the CARARE project is the rendering of 3D models online for general users. 3D digitisation of large buildings or monuments often results in very large volumes of data and heavy-weight models, which are too large for presentation on the web. Such models may be made available off-line on standalone systems, or they may be converted (simplified) for presentation on the web. Current best practice guidance recommends the use of VRML, X3D and Collada as standardised formats with longevity [25] [26]. These are very good choices for digital preservation but viewing models in these formats still involves users in installing browser plug-ins, and as the plug-ins are not browser independent different plug-ins need to be offered by content providers. Embedding 3D models into PDF documents may offer a cross-platform solution that enables this content to be viewed without the need to install plug-ins. CARARE plans to make recommendations to Europeana content providers on the selection of suitable visualisation technologies which offer users a satisfying experience of 3D content.

## 7 Getting Started

The CARARE project started on the 1st February 2010 and, at the time of writing, the project start-up phase is underway. Working groups are meeting to discuss and make

recommendations on metadata and vocabularies, and work is in progress to establish the CARARE repository and technical architecture.

A survey has been initiated to gather information from CARARE content providers about the content that they will be making accessible to Europeana and about their technical situations. We know that our partners are starting from different points, with a few already having advanced interoperable and remotely accessible online services while others need to set up their OAI-PMH repositories from scratch. Over the coming months as the survey brings more information about the situations of individual partners, CARARE will develop the advice, guidance and support needed to prepare for harvesting.

The CARARE aggregator will be implemented and tested during 2010, with trial harvesting from our content providers beginning towards the end of the year. Live harvesting will commence in 2011 with CARARE's first set of 2D contents becoming accessible to Europeana users with the Danube release in summer 2011.

## 8 Conclusions

With CARARE we are at the beginning of an exciting project which constitutes the next step on a journey towards realising the dream of bringing together Europe's archaeological and architectural heritage in a single access point which enables research across borders. We are building on previous work on data standards, terminology and technical infrastructure, and the efforts of heritage organisations, museums and research institutions to digitise the historic environment.

**Acknowledgements.** CARARE is a project in which 28 organisations participate. The authors gratefully acknowledge the contributions of Rob Davies of MDR Partners, Lena Inger Larsen and Christian Ertmann-Christiansen of Kulturarvsstyrelsen, Vasilis Tzrouvaras of the National Technical University of Athens, Dimitris Gavrilis and Christos Papatheodorou of the Digital Curation Unit, Athena Research Centre, Oliver Mamo of Heritage Malta, Sven Ole Clemens of the Deutsche Archaeologisches Institut, Maria Emilia Mascii of the Scuola Normale Superiore and all the members of the CARARE metadata working group.

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